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CHEMICAL STIMULATION AND THE EVOLUTION OF CARBON DIOXID.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLIV.

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(WITH TWO FIGURES)

SEVERAL years ago, in a study by Kahlenberg and myself[1] of the effect of placing small pieces of various chemical elements in water where seedlings were growing, it was found that in a considerable number of instances the roots of the seedlings exhibited an acceleration of growth, which we construed as an effect of the chemical employed. In individual cases we found a rapid elongation of the primary root, probably resulting from the action of Bi, Cr, In, Se, Te, Hg, Bo, Pb, W, Co, and Cu. This abnormally rapid growth was frequently followed promptly by death. As the compounds of these elements began to enter into solution, their first action on the plant was that of stimulants; when these same compounds became more concentrated, they became distinctly, often fatally, toxic.

The stimulating action of minute quantities of various poisons has long been known in the case of a few fungi. Raulin[2] found that salts of Zn, Fe, and Mn, as well as silicates, caused an unusually luxuriant growth of Aspergillus. Richards[3] extended

[1] COPELAND, E. B., and KAHLENBERG, LOUIS, The influence of the presence of pure metals upon plants. Trans. Wisc. Academy **12**: 454–474. 1899.

[2] RAULIN, J., Études chimiques sur la végétation. Ann. Sc. Nat. Bot. V. **11**: 93–299. 1869.

[3] RICHARDS, H. M., Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30**: 665–688. 1897.

Raulin's observations, using Aspergillus, Penicillium, and Botrytis as subjects, and Zn-, Fe-, Co-, and Ni-sulfates, NaFl, LiCl, Na_2SiO_3, cocain, morphin, and amygdalin as stimulants. He also recognized the phenomenon in its true light, as one of stimulation. Ono[4] used almost exclusively the same salts and $HgCl_2$ in addition, with the same results as Richards. Richter,[5] from work with a wide range of concentrations, regards the Zn ion as stimulating the growth of Aspergillus, but the ZnSO molecule as depressing it, and recognizes no acceleration under the influence of Cu. Pulst[6] added Mucor to the list of subjects, and Cd and Tl to the list of poisons which stimulate growth if sufficiently dilute. Hattori[7] has also found abnormally active growth of fungi in $CuSO_4$ solutions, De Seynes[8] describes a strain of Penicillium thriving in it, and Gosio[9] reports Mucor, Aspergillus, and another strain of Penicillium thriving in the presence of arsenic. Similar observations to Gosio's were made long ago by Preuss[10] and Bouchardat.[11] Yasuda[12] finds that the addition of suitable amounts of alkaloids to the nutrient solutions favors the growth of molds, the mode of action, whether as food or stimulant, not being determined.

Turning to plants other than the fungi, a similar stimulating

[4] ONO, N., Notes on the stimulating effect of certain substances upon the growth of algae and fungi. Bot. Mag. Tōkiō **14**: 75–78. 1900. Also, Ueber die Wachsthumsbeschleunigung einiger Algen und Pilze durch chemische Reize. Jour. Coll. Sc. Imp. Univ. Tōkiō **13**: 141–186. 1900.

[5] RICHTER, A., Zur Frage der chemischen Reizmittel. Centralbl. Bakteriol. **7**: 417–429. 1901.

[6] PULST, C., Die Widerstandsfähigkeit einiger Schimmelpilze gegen Metallgifte. Jahrb. Wiss. Bot. **37**: 205–263. 1902.

[7] HATTORI, Studien über die Einwirkung des Kupfersulfats auf einige Pflanzen. Jour. Coll. Sc. Imp. Univ. Tōkiō **15**: 371–394. 1901.

[8] DE SEYNES, J., Resultats de la culture du *Penicillium cupricum* Trabut. Bull. Soc. Bot. France **42**: 451–455, 482–485. 1895. [Bot. Centralbl. **66**: 157.]

[9] GOSIO, B., Zur Frage, wodurch die Giftigkeit arsenhaltiger Tapeten bedingt wird. Ber. Deutsch. Chem. Ges. **30**: 1024–1026. 1897.

[10] PREUSS, Wirkung des Arseniks auf Vegetabilien. Bot. Zeit. **6**: 409–412. 1848.

[11] BOUCHARDAT, Recherches sur la végétation appliquées à l'agriculture. Paris, 1846. Rev. in Bot. Zeit. **5**: 85, 102. 1847.

[12] YASUDA, A., On the effect of alkaloids upon some moulds. Bot. Mag. Tōkiō **15**: 79–83. 1901.

action of dilute poisons, well established in those organisms physiologically nearest them, the bacteria, led Hueppe[13] to the formulation of this "biologischen Grundgesetz:"

Jeder Körper, der in bestimmter Concentration Protoplasma tödtet und vernichtet, in geringeren Mengen die Entwickelungsfähigkeit aufhebt, aber in noch geringeren Mengen, jenseits eines Indifferenzpunktes, umgekehrt als Reiz wirkt und die Lebenseigenschaften erhöht.

Ono (*l. c.*) detected an acceleration of the growth of algae by all the same substances to which his fungi responded, except Hg; but found the optimum concentration much lower, corresponding to the greater susceptibility of the alga to injury by these poisons.

Our information on the chemical stimulation of the growth of phanerogams is altogether fragmentary. The most familiar example of this is the exceptionally luxuriant growth of violets and some other plants in the neighborhood of zinc works. Rumm[14] finds that in grape vines sprayed with copper various leaf tissues become better developed, and the fruit ripens earlier. Berlese and Sostegni[15] substantiate this, but seem to believe that the most important immediate effect of the copper is the increase of the cyanophyll, other effects being results of this. Frank and Krüger[16] show that potatoes sprinkled with copper solutions excel in leaf area, length of life, and amount of crop. Townsend finds that the growth of Avena seedlings is accelerated at least temporarily by not too much ether in the atmosphere;[17] that the germination of various seeds and spores may be hastened

[13] HUEPPE, F., Naturwissenschaftliche Einführung in die Bakteriologie. Wiesbaden. 1896. Hueppe gives Arndt and Schultz joint credit with himself for this generalization.

[14] RUMM, C., Ueber die Wirkung der Kupferpräparate bei Bekämpfung der sogenannten Blattkrankheit der Weinrebe. Ber. Deutsch. Bot. Gesells. **11**: 79–93. 1893.

[15] BERLESE et SOSTEGNI, Recherches sur l'action des sels de cuivre sur la végétation de la vigne et sur le sol. Rev. internat. de Vitic. et Oenologie. 1895. [Bot. Jahresber. **23**[1]: 292–294. 1895.]

[16] FRANK, B., und KRÜGER, F., Ueber den Reiz welchen die Behandlung mit Kupfer auf die Kartoffel hervorruft. Ber. Deutsch. Bot. Gesells. **12**: 8. 1894.

[17] TOWNSEND, C. O., The correlation of growth under the influence of injuries. Ann. Botany **11**: 509–532. 1897.

by weak enough ether,[18] and that germination and subsequent growth can be accelerated by a short exposure to HCN gas.[19] Lövinson[20] discovered that germination was hastened by CS_2. De Toni and Mach[21] are said to get the same result by treating tobacco seeds with alkaloids; Windisch[22] finds that $Ca(OH)_2$, though damaging to some kinds of seeds, improves the germination of oats; and Böttger[23] has hastened the germination of coffee with dilute KOH. Kahlenberg and True[24] found that in acid solutions their seedlings had a tendency toward abnormally rapid growth, followed by death; but experiments on this point with HCl yielded only negative results. An unsigned note[25] in an old Flora says:

> Bekanntlich können Samen, welche schwer keimen, oder die Fähigkeit dazu bereits verloren haben, dadurch zum Keimen gebracht werden, dass man dieselben längere Zeit in mit Salzsäure schwach angesäuertes Wasser legt.

This is followed by a review of work, the original publication of which in "Silliman's Journal" I have not located, on seeds treated with very dilute HCl. *Lactuca sativa* in these experiments was two and one-half inches high in 48 hours, and in eight days had reached the state of development normally requiring five or six weeks; and young pines and firs grew so, that, at the end of three months, they were taken for two years old.

[18] TOWNSEND, C. O., The effect of ether upon the germination of seeds and spores. BOT. GAZ. **27**: 458–466. 1899.

[19] TOWNSEND, C. O., The effect of hydrocyanic acid gas upon grains and other seeds. BOT. GAZ. **31**: 241–264. 1901.

[20] LÖVINSON, O., Ueber Keimungs- und Wachsthumsversuche an Erbsen in Lösungen von fettsauren Salzen unter Ausschluss von Mineralsäuren. Bot. Centralbl. **83**: 1, 33, 65, 97, 129, 185, 210. 1900.

[21] DETONI, B. G., e MACH, P., Sopra l'influenza esercitata della nicotina, etc. Boll. R. Ist. Bot. Univ. Parmiense. 1893. Not seen.

[22] WINDISCH, R., Ueber die Einwirkung des Kalkhydrates auf die Keimung. Landw. Versuchsst. **54**: 283–309. [Bot. Centralbl. **87**: 217.]

[23] BÖTTGER, R., Beförderung des Keimprocesses. Jahresb. phys. Ver. Frankfurt. 1872-3. [Bot. Jahresber. **1**: 833. 1874.]

[24] KAHLENBERG, L., and TRUE, R. H., On the toxic action of dissolved salts and their electrolytic dissociation. BOT. GAZ. **22**: 81-124. 1896.

[25] Beförderung des Wachsthums der Pflanzen durch Salzsäure. Flora **28**: 464. 1845.

Immediately following the before-mentioned work by Kahlenberg and myself in the spring of 1899, I started a series of water cultures in which Zn and Cu were present. The results were such as to encourage a continuance of the work, and showed that the acceleration of growth is most decided by solutions not a great deal more dilute than those that are distinctly toxic. In fact, the concentrations producing the two effects differed by less than the individual variations of the seedlings used, so that, as in our earlier work when the metals themselves were placed in the water, it sometimes happened that in the same culture (vessel) some plants were evidently injured, while others grew exceptionally well. It is evidently reasonable, even if out of accord with our usual way of looking at it, to regard the acceleration of growth as itself an injury to the plant.

In the summer of 1899 appeared Jacobi's[26] work on the influence of various substances on the respiration and assimilation of water plants. I was immediately impressed with the superiority of respiration to growth as a true index of the plant's activity. I need not enter into a discussion of the relation of respiration to the plant's multifarious other manifestations of activity. It makes available the energy for most of them; without it all would cease. Growth is dependent on respiration, and under ordinary conditions they vary together; when they do not, it is respiration which reveals the plant's real activity. From the minimum to the optimum temperatures for growth, its curve rises with that of respiration, the more rapid combustion in the plant furnishing more energy and proper material for growth. But the more active the respiration, the less the *relative* amount of plastic material left available for growth. A point must be reached, then, beyond which an increase in respiration can reasonably be regarded as itself the cause of a decrease in growth. This is what happens at temperatures above the optimum for growth. How far this loss of material can go during the most rapid respiration is shown by Kraus's[27] classic work, in

[26] JACOBI, B., Ueber den Einfluss verschiedener Substanzen auf die Athmung und Assimilation submerser Pflanzen. Flora **86**: 289–327. 1899.

[27] KRAUS, G., Ueber die Blüthenwärme bei *Arum italicum*. Abhandl. Naturf. Gesells. Halle **16**:—. 1884. Also, Ueber Blüthenwärme bei Cycadeen, Palmen und Araceen. Ann. Jard. Bot. Buitenzorg **13**: 217–275. 1896.

which he found as much as three-fourths of the substance of some spadices consumed within a few hours; yet respiration need not use up the combustible material at any rate comparable to this to make constructive growth impossible.

Exactly the same phenomenon should be anticipated when respiration is accelerated by a chemical stimulus as when heat is the agent. The result of moderate stimulation will be a quickening of the growth, but with a more violent stimulation of the respiration, growth will be hindered and ultimately stopped. Wherever my work has thrown any light on this question, it has made this view seem more certainly the correct one. The more concentrated the solutions used, the more is the respiration accelerated, even when the concentration is fatal in twenty-four hours or less. In the isolated case in my experiments, in which with increasing concentration there was an initial decrease in the respiration, the solution was so strong as to plasmolyse the cells violently, and the result was without doubt due to the osmotic (physical) action. In the relatively few instances in which it has been sought, an optimum concentration for vegetative growth has always been determined, and the known antagonistic effect of considerably greater concentrations than those accelerating growth shows that an optimum must exist for each stimulant and plant. An optimum concentration of a chemical stimulant for respiration is not known in a single instance; it does not exist.

The "biologische Grundgesetz" of Hueppe is not fundamental. It applies only to growth, or to growth and other phenomena standing in the same relation with it to respiration. It means merely that when respiration is not already too active, accelerating it will result in a quicker growth. It is indifferent whether the accelerating agent be chemical or thermal. The explanation I have offered of the opposite effects on growth of dilute and more concentrated solutions would do away entirely with Richter's idea that the difference is because ions stimulate, but molecules poison. As already stated, no difference exists except in degree between solutions of different strength in their action on respiration. Richter's explanation is difficult to

harmonize with the details of the degrees of dissociation, since dissociation is very nearly complete in fatal concentrations of several poisons (Kahlenberg and True, 1896). And it fails utterly to explain the rather abrupt change from accelerating to obviously toxic concentrations. This quick change has, from my point of view, a perfect analogue in the plant's thermal relations in the steep fall of the curve of growth above the optimum temperature. Even the ion theory can be overworked.

If we interpret the action of chemical stimuli on growth as secondary to that on respiration, we are already armed with an explanation of their influence on reproduction. Klebs[28] has shown that the demands of reproduction upon various conditions are more strict than those of growth. This may be regarded as meaning, in part at least, that the balance of available plastic matter must be relatively great, while the sacrifice of matter for energy must be less than is tolerable for growth. The optimum temperature for reproduction would then be sought below that for growth, and a chemical stimulus accelerating growth might inhibit reproduction. From Klebs[29] again, we know that while the optimum for growth of *Vaucheria repens* is 30° C., the maximum for the formation of zoospores (p. 46) and for sexual reproduction (p. 112) is about 26° C. This idea might still be sound, even if it should be shown that the least perceptible quantity of a poison interfered with reproduction. Of course I offer this only as a suggestion, and do not overlook the very likely alternative that acceleration of the growth is the factor which in its turn injures the reproduction. Of course, too, there are outside factors which act on the growth quite independently of the respiration. The blue end of the solar spectrum slackens growth, but has no well authenticated direct effect on respiration. In the case of all chemical stimuli, however, so far as they are known at all, I hold it more than probable that their apparent effect on growth is a function of their more direct influence on respiration.

[28] KLEBS, G., Einige Ergebnisse der Fortpflanzungs-Physiologie. Ber. Deutsch. Bot. Gesells. **18**:(201)–(215). 1900.

[29] KLEBS, G., Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. Jena. 1896.

I have intercalated this discussion at this point, in advance of the evidence on which my opinions are partly based, in order that the primary position of respiration in the plant's economy, and its eminent fitness as a field of study in chemical irritability might be clearly in mind. The importance of respiration will not be at all impaired if the view well maintained in animal physiology by Loeb and others, which regards the energy relations characteristic of living things as electrical rather than thermal, is found altogether correct.

While there is an extensive literature on the influence on respiration of sugars and other substances which furnish the plant with material to be oxidized, there has been surprisingly little work done with chemicals acting primarily as stimulants. The most considerable collection of such data is that of Jacobi, who tested the effect of KNO_3, KCl, NaCl, chinin, antipyrin, I, oxalic acid, and $CuSO_4$ on the respiration of Elodea and Myriophyllum. Some of these substances were given but a single test, and none of them were tried in any considerable range of concentrations. Previous to Jacobi, Kellner[30] had found an acceleration in the respiration of pea seedlings by treating them with KNO_3, and attributed it to direct oxidation by the O of the saltpeter. Elfving,[31] Lauren,[32] Johannsen,[33] and Morkowine,[34] have demontrated the acceleration of respiration by anesthetics. Morkowine[35] has also extended Jacobi's work on the action of alkaloids. Mayer[36] reports that HCN reduces the activity of respiration, as

[30] KELLNER, O., Ueber einige chemische Vorgänge bei der Keimung von *Pisum sativum*. Landw. Versuchsst. **17**: 408. 1874. [Bot. Jahresb. **1**: 828. 1874].

[31] ELFVING, F., Ueber die Einwirkung von Aether und Chloroform auf die Pflanzen. Finska Vetensk. Soc. Förh. **28**: 36. 1886. I have not seen this paper.

[32] LAUREN, W., Ueber den Einfluss von Aetherdämpfen auf die Athmung von Keimlingen. Helsingfors. Diss. 1891. [Bot. Jahresb. **20**[1]: 92. 1892.]

[33] JOHANNSEN, W., Aether- und Chloroformnarkose und deren Nachwirkungen. Bot. Centralbl. **68**: 337–338. 1896.

[34] MORKOWINE, N., Recherches sur l'influence des anesthésiques sur la respiration des plantes. Rev. Gén. Bot. **11**: 289–352. 1899.

[35] MORKOWINE, N., Recherches sur l'influence des alcaloides sur la respiration des plantes. Rev. Gén. Bot. **13**: 109, 177, 212, 265. 1901.

[36] MAYER, AD., Ueber den Einfluss der Blausäure auf Pflanzenathmung. Landw. Versuchsst. **23**: 335. 1879.

KCN is believed to do in animal physiology. Diakonow[37] states that with increasing acidity of the nutrient medium intramolecular respiration of molds decreases, but normal respiration is not sensibly affected. Kosiński[38] finds the respiration of Aspergillus quickened by Zn, Fe, Mn, cocain, strychnin, and not too concentrated ether; he tested $ZnSO_4$ as strong as 0.1 per cent. without its depressing the respiration during the first day. He also reports a stimulation by .0005 per cent. $ZnSO_4$, but this appearance is quite possibly due to the growth of his material, as appears more probable from his finding the acceleration not very dependent on the concentration of salt applied. Ono (*l. c.* 1900, p. 156) found that the proper concentration of $NiSO_4$ increased the formation of oxalic acid, but got a similar result with no other poison. The acceleration of fermentation by yeasts, by the presence of traces of poisons, is a very nearly related phenomenon.

In my measurements of respiration I have used a modification of the Pettenkofer method, which has enabled me to work with an assurance of reliable results not possible with apparatus hitherto used. Respiration varies rapidly with changes in temperature, and absolute constancy of temperature is not practicable. The best we have been able to do is to make the variations as slight as possible; and in studying the influence of other factors on respiration, the error from the thermal variations has had to be ignored. Working with water plants this error is augmented by the lesser solubility of CO_2 at higher temperatures. The rate at which air passes through the apparatus has a more than appreciable influence on the results under any conditions; and when working with solutions the solubility of the CO_2 makes glaring the results of small irregularities in the rate of flow. When experiments are lasting longer than a few hours the rate of respiration may change, and the possible error from this source is very imperfectly overcome when, with other plants,

[37] DIAKONOW, N. W., Intramolekulare Athmung und Gährthätigkeit der Schimmelpilze. Ber. Deutsch. Bot. Gesells. **4**: 2–7. 1886.

[38] KOSIŃSKI, I., Die Athmung bei Hungerzuständen und unter Einwirkung von mechanischen und chemischen Reizmitteln bei *Aspergillus niger*. Jahrb. Wiss. Bot. **37**: 137–204. 1901.

under conditions which it is hardly possible to make identical, the respiration is found constant.

I had been but a few weeks at this work before irregularities in my results, which I could not prevent, and often could not account for—just such irregularities as cast a suspicion on more than one piece of work on respiration—made it very evident that sound results on respiration are not to be obtained without the same precaution in the use of parallel controls which is regarded as indispensable in other fields of physiology. So far as I know, the only work in which a real control has been used in experiments on respiration is that of Moller,[39] whose apparatus is in that respect more worthy of imitation than the widely followed one of Pfeffer and Wilson.[40]

The apparatus which I have used is illustrated by the accompanying diagram (*fig. 1*). The subjects of experiment are submerged in water in a large can. In the early part of the work, I used in place of this can a large stone churn, black inside, with a turned wooden lid soaked in India ink, and plugged the openings around the connections with cotton similarly soaked; but I have since satisfied myself that the light in the interior of the laboratory will not disturb the experiment if no care at all is taken to exclude it from the can. The air comes to both bottles of experiment material after the removal of all CO_2 by passing two towers of solid KOH and a solution of $Ba(OH)_2$. From each subject of experiment the air passes to a bottle, in whose stopper are four holes, which serves admirably, and without taking more than a minimum of room, as a switch board. When the experiments were carried on at a much higher temperature than that of the room, these bottles contained H_2SO_4 to prevent the dilution of the baryta water by distillation from the experiment bottles. In the diagram the absorption tubes are Winkler coils. I have used them and Pettenkofer tubes about equally, and have no choice, except that with the

[39] MÖLLER, H., Ueber Pflanzenathmung. Ber. Deutsch. Bot. Gesells. **2**: 306–321. 1884.

[40] PFEFFER, W., Ueber intramolekulare Athmung. Unters. Bot. Inst. Tübingen **1**: 636–685. 1885.

latter it is not easy to keep the glass tube by which the air enters the baryta water free of $BaCO_3$. It is not difficult to keep either kind of tube clean if it is always washed, after using, with *dilute* HCl. Using two absorption tubes with each culture, the experiment is continuous, only a few seconds being used in switching the currents of air. From the absorption tubes the air passes to another switch board bottle containing some H_2SO_4. A tube directly from one switch board bottle to the other makes it possible to keep air passing through the cultures without using the absorption tubes; but this was found inadvisable and was largely given up, because when the absorption tube is returned to use, the height of liquid in it slackens the flow of air, and the irregularity so introduced is not immediately overcome by lengthening the siphon by an equal height of liquid. The glass stop cocks to which the air passes next regulate its rate of movement. These cocks must be selected by experience, and once they are working well must not be touched. The H_2SO_4 in the bottles below them prevents their obstruction by the precipitation of water.

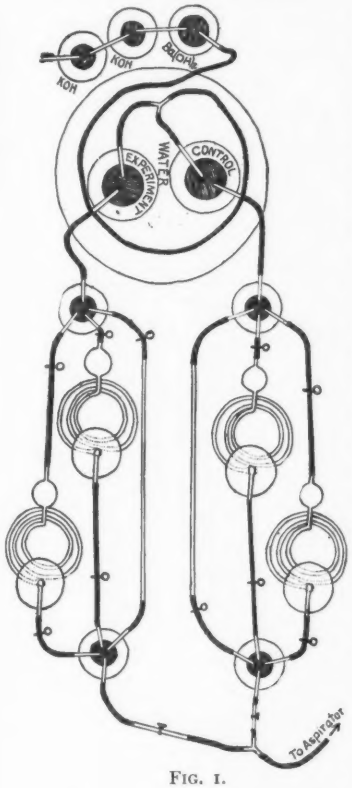


FIG. 1.

As aspirators I have used barrels, and latterly a metal cask holding 200 liters, the vessel always having a lateral bung so that it might lie on its side. With this aspirator it was possible to run air at the speed I chose, usually about three liters per hour, through both cultures for over thirty hours. It was always filled (the filling requiring but few minutes) the last thing at night, and the effect of the interruption was lost in the long

interval before the next change of solutions. The volume of water in these aspirators was so great that the surface sank very slowly; and with a siphon over two meters long the loss of the effective pull was so slow that it could have had but little influence on the result if neglected; but even this I tried roughly to correct by lengthening the siphon as the day passed.

The siphon was a glass tube with the largest bore, almost 3^{mm}, with which the stream would be certain to carry down any bubble forming in it. The siphon could carry water from the aspirator so rapidly that the limited rate at which air enters the latter has no great influence on the pressure in it, and almost the whole pull of the siphon is exerted against each of the glass stop cocks. Any attempt to regulate the flow in the usual way, by restricting the siphon, reduces the suction in the aspirator; then the more rapid movement of air through one culture, the slower it is through the other. I have found it utterly impossible to balance the resistance in the two parts of the experiment so perfectly that they would keep the balance through the whole time of an experiment, except in the way described, by having the same high and steady suction act constantly on both.

The baryta water was put into the absorption tubes with the apparatus at the left of *fig. 2*. From the large bottle of stock solution it was allowed to run into the tube *A* until the fine tube in the top of this just broke the meniscus. The escape was then connected by a rubber joint with the small end of the absorption tube, and the liquid allowed to run out until the tube inserted in the lower end of *A* broke the meniscus; this measured out 100^{cc} without its coming in contact with any CO_2 except in the air in the absorption tube. Of course the stale baryta water standing in the escape of *A* was washed out just before the tube was filled. No baryta water was allowed to stand in the small bulb of the Winckler tubes.

After each interval of experiment the solution used was poured from the absorption tube into a bottle holding a little over 100^{cc}, without exposure to air except that in the bottle; and the bottle was immediately placed in the position of *B* in *fig. 2*, or else stoppered. If respiration had been active enough

to form a visible precipitate, this was allowed to settle, and the solution then siphoned into *C*. As one-third of the baryta water used was ordinarily more than was needed for titration, I was

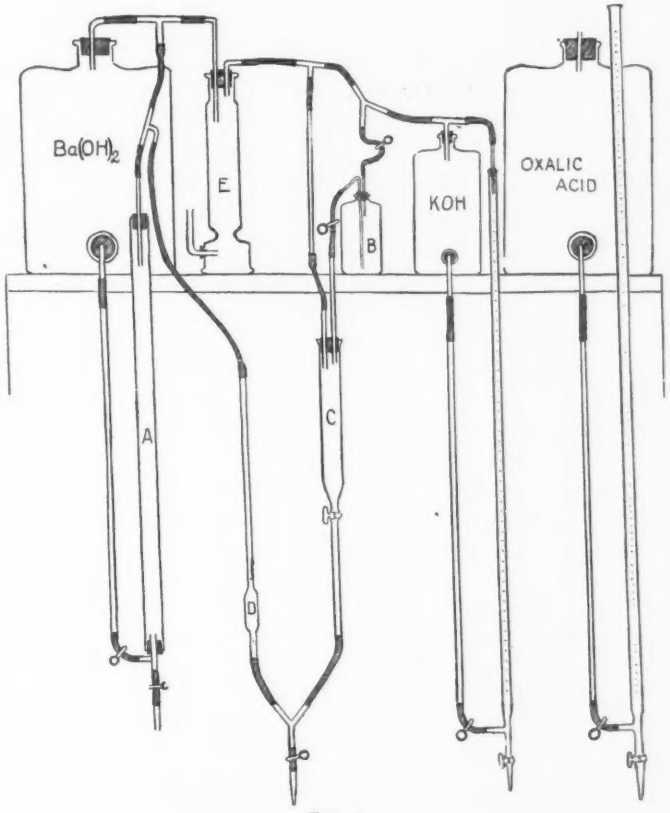


FIG. 2.

able to use it freely in washing out the apparatus before beginning to measure it. For the actual measurement I used the "burette" *D*, which I blew from heavy tubing with a bore of less than 3^{mm}; from the scratch above the bulb to that below is exactly 10^{cc}. The titrating was done in 100^{cc} bottles, with perforated corks. Two drops of neutral alcoholic phenolphthalein

were put in the bottle, which was then corked; 10^{cc} of the solution to be tested were run from *D*, whose outlet was stuck through the cork; then the outlet of the burette containing oxalic acid was stuck through the cork and enough run in to just neutralize. The acid was run in cautiously enough so that the color disappeared with the final addition of a single drop; this made it unnecessary to titrate back, though a burette of KOH of the proper strength was always ready for use if needed. As the diagram (*fig. 2*) shows, every vessel of any kind containing an alkaline solution can communicate with the air only through the tower *E*, containing pumice soaked in KOH.

For the idea of this method of titrating I am indebted to Symons and Stephens.[41] When, as in this work, extreme accuracy is necessary, titrating in a flask closed with the thumb, as is directed in manuals of quantitative analysis, yields serious irregularities; and when the liquid to be tested is measured by a pipette into which it is sucked, the results are not even tolerably uniform. Using the common method I often made five determinations of the titre to get a "reliable" average. The first two are likely to agree entirely, and almost never vary by more than one drop (0.05^{cc}); when they agree I call any more tests superfluous. This accuracy is the more notable because the acid used was $\frac{N}{100}$. The usual method of determining the CO_2, in milligrams, has no recommendation except custom; expressing it in volume of a normal solution is in much better harmony with modern chemical methods. My acid was practically 0.44, as strong as the most dilute one commonly used, of which 1^{cc} is the equivalent of 1^{mg} CO_2. It permits therefore more than twice the accuracy.

The limit of positive accuracy in volumetric analysis is one drop of the strongest solution in use. The directions extant for making up the baryta water provide for its being several times as strong as the acid it is titrated with. To get the benefit of the use of very dilute acid I have also used weak baryta water, not more than twice as strong, at the most, as the $\frac{N}{100}$ acid,

[41] SYMONS, W. H., and STEPHENS, F. R., Carbon dioxide. Its volumetric determination. Journ. Chem. Soc. London **69**: 869–881. 1896.

except in experiments in which I anticipated a tremendous evolution of CO_2. Such dilute baryta water still removes all CO_2 from the air.

As subjects of experiments in this work I have used Cardamine, Callitriche, Ceratophyllum, Potamogeton, Elodea, tadpoles, and fish (an immature cyprinoid, not determined). Elodea and tadpoles were the subjects of extended series of experiments, the other plants and the fish being used but a few times, to be sure of the general validity of the results.

In three changes of residence since doing the work with tadpoles I have misplaced the detailed results of the individual experiments on them. The solutions used on them were all dilute enough not to be fatal during the time of experiment, and their results agree in all essentials with those yielded by similar work on Elodea. Single experiments with the chlorids of gold and platinum on tadpoles failed to show any influence on the evolution of CO_2, probably because they were used in too great dilution. With $CoCl_2$ the evolution of CO_2 was accelerated. The other chemicals employed, Zn, Cu, Cd, and Hg, were used again on Elodea. Because of this, and of the question I will present shortly as to the significance of any of the results with strong metallic poisons, I do not think it worth while to hunt up and publish the detailed results on tadpoles. Nor will I consume space with any considerable part of the detailed results on other subjects. In the work with animal subjects, solutions much too weak to kill them stimulated them to a visibly increased muscular activity. This was most pronounced, with relation to the toxicity of the several metals, with Cd, a little less by Cu, and least of all the substances used by Pt, in which the tadpoles were very sluggish, in spite of the acidity of the "$PtCl_4$" employed. It seemed to me, from a comparison of the results obtained at the same time on tadpoles and on Callitriche, that the excited muscular activity of the former did not produce a relatively greater evolution of CO_2; from which I concluded that the protoplasm of both was stimulated equally, the plant's response being, for obvious reasons, less conspicuous.

A study of the acceleration of respiration would be blind

reading, without accompanying information on the toxicity of the chemicals used. By the fragmentary condition of our knowledge on this subject, I have been obliged to determine for myself the toxicity of these substances for the different organisms, and have compiled tables on the tadpole, Callitriche, and Elodea, of which the two former may be omitted, with the corresponding statistics on respiration. These experiments on Elodea were made with young growing tips, 2–4^{cm} long. The condition of the plant, dead or alive, was determined by trying to plasmolyze the youngest grown leaves in KNO_3. Relieved of details as to concentrations which do not seriously injure or are stronger than enough to kill, the results follow, the figures being the number of liters of solution in which one gram-molecule is imagined distributed.

$Pb(NO_3)_2$ Alive but hardly sound after 24 hours in $\frac{M}{10}$. Appears normal in $\frac{M}{25}$.

KCN Dead in 30 hours in $\frac{M}{100}$, but alive in $\frac{M}{200}$.

KOH Dead in 2 hours in $\frac{M}{100}$: in one test dead, in another almost so after 24 hours in $\frac{M}{200}$.

$NiCl_2$ Dead in 24 hours in $\frac{M}{100}$: somewhat unsound in $\frac{M}{200}$.

$ZnSO_4$ Dead in three hours in $\frac{M}{100}$: alive but unsound after 26 hours in $\frac{M}{200}$: sound indefinitely in $\frac{M}{500}$, below 20° C.

HCl Dead in 15 hours in $\frac{M}{500}$: unsound after 24 hours in $\frac{M}{1000}$.

$CoCl_2$ Practically dead after 24 hours in $\frac{M}{10,000}$.

$Cd(NO_3)_2$ Almost dead after 24 hours in $\frac{M}{20,000}$: sound in $\frac{M}{40,000}$.

$CuSO_4$ Dead in 25 hours in $\frac{M}{20,000}$: alive in $\frac{M}{40,000}$.

$HgCl_2$ Sound after 5 hours in $\frac{M}{40,000}$, but dead in 30 hours in $\frac{M}{80,000}$.

$AgNO_3$ Dead in 24 hours in $\frac{M}{160,000}$: unsound in $\frac{M}{320,000}$.

These determinations were made at a temperature of about 20° C.

K is a shade less poisonous than Pb; Na, a little less still, compared as nitrates. With the tadpoles, Pb and Cd were more

toxic than with Elodea, but Co is less so. $PtCl_4$ was not more toxic than could be ascribed to its acidity; gold chlorid was about equally so; and uranyl (nitrate) was about as toxic as Co. KCN was not tested on tadpoles, but would certainly not have been found harmless as with Elodea. My KCN was strictly *p. c.*, and was about 0.7 as alkaline as equivalent KOH. Their toxicity toward Elodea is about proportional to their alkalinity.

The modern work on the toxicity of inorganic salts to higher plants is not as conclusive and satisfactory in its botanical as in its chemical aspects. At least in large part it has been done without reference to the temperature. But I have found, as was *a priori* reasonable, that at 28° C., and still more at 37.5° C. (at which the temperature alone is fatal in time), Elodea succumbs much more readily than below 20° C. If an arbitrary time limit, say 24 hours, is placed on the experiment, it is evident that the higher the temperature the more toxic the substances tested will appear. Beside this, I have some evidence, though not enough to be conclusive, that at higher temperatures the adaptation to the poison does not increase in rapidity in proportion to the injurious action; when this is true, the plant may become adapted and thrive in a solution at a lower temperature, which at a higher would kill it.

The range of variation in apparently reliable statements as to the toxicity of the same substances with different organisms is nothing short of astounding. Kahlenberg and True place Cu, Fe, Ni, and Co on a par, as to their action on *Lupinus albus*. Heald[42] finds Ni and Hg equally toxic to Zea. Coupin[43] says $CuSO_4$ diluted to 1 (mol.?) in 700,000,000 checks the growth of wheat, while $AgNO_3$ acts likewise when 1 in 1,000,000, and

[42] HEALD, F. D., On the toxic effect of dilute solutions of acids and salts upon plants. BOT. GAZ. **22**: 125–153. 1896.

[43] COUPIN, H., Sur la sensibilité des végetaux supérieurs à des doses très faibles des substances toxiques. Comptes Rendus, Paris **132**: 645–647. 1901. Coupin claims priority for the discovery that distilled water is not in itself a poison, having published it in 1900 (Cf. de Clèves, L'eau distillée, est-elle pure? in La Nature **28** 1: 196. 1900), and DEHÉRAIN and DEMOUSSY (Compt. Rend. **132**: 523–527. 1901), having repeated it. The fact was not new by some years when Kahlenberg and I did our work in 1898 (published in 1899).

$Pb(NO_3)_2$ when 1 in 100,000. From the Pb and Ni results Elodea (and Callitriche) would seem very resistant as compared with other flowering plants; and in fact the tabulated results as a whole justify that view. And yet it ranks with the most sensitive when treated with Hg or Ag.

[*To be concluded.*]

THE GENUS CRATAEGUS IN NEWCASTLE COUNTY, DELAWARE.

CHARLES S. SARGENT.

THESE notes are based on collections and observations of the genus Crataegus made during the last three years in Newcastle county, Delaware, by Mr. W. M. Canby.

CRUS-GALLI.

Stamens 10.

CRATAEGUS CRUS-GALLI Linnaeus.— Near Wilmington the typical form of this species is common. It is a glabrous tree with wide-spreading branches, obovate coriaceous leaves with the primary veins mostly within the parenchyma, 10 stamens, bright rose-colored anthers, and sub-globose or short-oblong dull crimson fruit which often remains on the branches late into the winter or until spring. The leaves on short lateral branches are clustered and erect, while the long and numerous spines mostly point downward. In the middle states, however, there are many perplexing forms of this species; some have more or less hairy corymbs; of others the fruit varies in size, shape, and brightness of color; of others the leaves are thinner, nearly always acute and sharply serrate, with more prominent veins, and occasionally individuals are found nearly destitute of thorns. Some of the most distinct of these varieties may be characterized as follows:

CRATAEGUS CRUS-GALLI **oblongata,** n. var.—Fruit oblong, often 2.5^{cm} in length, rather brighter colored than the fruit of the type; nutlets 1 or 2, acute at the ends, prominently or often only slightly ridged on the dorsal side, 10 to 11^{mm} long.

Meadow near Edgemoor, *W. M. Canby*, September 30, 1899, June 3, 1901; Pennsylvania, Dunham, Bucks county, *C. D. Fretz*, October 1901, September 1902.

CRATAEGUS CRUS-GALLI PYRACANTHIFOLIA Ait. Sargent, Silva N. Am. **13**: 39. *t. 637*.—In this form the nutlets are also often solitary and are more acute than those of the typical form. Common.

CRATAEGUS CRUS-GALLI **capillata,** n. var.—Leaves oblong-obovate, rounded or acute at the apex, finely serrate, thin but firm in texture, lustrous on the upper surface, pale on the lower surface, about 3.5^{cm} long, 1.5 to 2^{cm} wide. Flowers small, rarely more than 8–10^{mm} in diameter, in many-flowered slightly villose corymbs; stamens 10; anthers pale rose color; styles usually 1, rarely 2. Fruit subglobose to short-oblong, green slightly blotched with red; nutlets 1, rarely 2, obtuse at the ends, prominently ridged, 8 or 9^{mm} long, nearly as thick as long.

A tree 3–4^{m} in height, with a trunk covered with dark rough bark, spreading branches, and slender nearly straight branchlets villose when they first appear, bright chestnut-brown and lustrous during their first season, becoming reddish-brown the following year, and armed with slender slightly curved bright chestnut-brown ultimately gray spines 3–6^{cm} long. Flowers during the first week of June. Fruit ripens toward the end of October and soon falls.

In woods one mile east of Christiana on the Newcastle road, *W. M Canby*, June 1 and October 16, 1901, May 31, 1902. A specimen in flower collected by Mr. Canby in a meadow at the head of the Wissahickon Drive, Germantown, Pennsylvania, appears to belong to this variety.

CRATAEGUS CANBYI Sargent, BOT. GAZ. **31**: 3. 1901; Silva N. Am. **23**: 41. *t. 638*.

Stamens 20.

Crataegus Pennypackeri, n. sp.—Leaves obovate, acute and often short-pointed at the apex, gradually narrowed and cuneate at the entire base, finely serrate above, with straight or slightly incurved gland-tipped teeth, glabrous, membranaceous until after the petals fall; at maturity subcoriaceous, dark green and lustrous above, pale yellow-green below, 3.5–4^{cm} long, about 2^{cm} wide, with pale light yellow midribs and primary veins impressed on the upper surface and raised and prominent below; petioles slender, grooved, winged above by the decurrent base of the leaf-blades, 8–10^{mm} long; leaves on leading shoots mostly rhombic, short-pointed, more or less deeply divided into broad acute lateral lobes, 8–9^{cm} long, about 7^{cm} wide, their stout

petioles wing-margined, 7–8^{mm} long, rather shorter than the foliaceous lunate acuminate coarsely glandular-serrate stipules. Flowers in compact many-flowered thin-branched compound corymbs covered with long scattered pale caducous hairs; calyx-tube narrowly obconic, the lobes narrow, acuminate, entire or occasionally obscurely glandular-serrate, reflexed after anthesis; stamens 20; styles 3–5. Fruit oblong, full and rounded at the ends, bright crimson marked by numerous large pale dots, 1–3^{cm} long, 8–12^{mm} wide; calyx prominent with a short tube, a broad deep cavity, and lanceolate lobes abruptly narrowed from broad bases, appressed; flesh thin, greenish, dry and mealy; nutlets 3–5, thick, obtuse, prominently ridged on the back, with a broad rounded ridge, 9–10^{mm} long.

An arborescent shrub 4–5^{m} high, with spreading branches and slender nearly straight or slightly zigzag branchlets marked by large oblong pale lenticels, pale yellow-green at first, light red-brown and lustrous during their first season, becoming gray-brown in their second year, and armed with many stout straight or slightly curved spines 5–6^{cm} long. Flowers from the middle to the end of May. Fruit ripens toward the end of September and in the beginning of October.

Banks of the spillway of Dean & Pillings's mill south of Stanton Station, *J. T. Pennypacker*, May 31, 1902, *W. M. Canby*, June 28 and Sept. 27, 1902.

PRUINOSÆ.

Stamens 20.

CRATAEGUS PRUINOSA K. Koch, Sargent, Silva N. Am. **13**: 68. *t. 648.*

Hedges, Eden Park, Wilmington, May and October 1899, May 1900, Elliott's Hill near Wilmington, October 1899; fields near Wilmington, May 1900; race bank below Stanton, September 1902; fence rows near Wilmington, September 1902, *W. M. Canby*. Common.

CRATAEGUS ARCANA Beadle, Biltmore Bot. Studies **1**^{2}: 122. April 1902.—Except by its slightly smaller flowers, I cannot distinguish from *Crataegus arcana*, of the elevated regions of western North Carolina, a common shrubby thorn of northern Delaware and eastern Pennsylvania, with thin leaves cuneate at the base except on vigorous shoots, twenty stamens, pale rose or light purple anthers, and fruits often obconic at the base and conspicuously swollen or mamillate below the middle.

Wood borders opposite Farnhurst, *W. M. Canby*, May, September, and October 1900; Pennsylvania, Chadsford, Chester county (with larger fruit), *W. M. Canby* and *B. H. Smith*, October 8, 1902; Sellersville, Bucks county, *C. D. Fretz*, May 1898, October 1899, May and September 1900, May 1901.

Stamens 10.

Anthers yellow.

Crataegus delawarensis, n. sp.—Glabrous. Leaves rhombic to ovate, acute, gradually narrowed below from near the middle or on vigorous shoots broadly cuneate at the entire base, divided above into three or four pairs of short acute lateral lobes and finely and sometimes double serrate, with gland-tipped teeth, membranaceous, light yellow-green on the upper surface, paler below, 5–6 cm long, 4–5 cm wide, with slender light yellow midribs and 3 or 4 pairs of thin primary veins arching to the points of the lobes; petioles slender, slightly wing-margined at the apex, grooved, glandular at first, with few small dark red deciduous glands, 2–3 cm long; stipules linear, acuminate, coarsely glandular-serrate, reddish, caducous. Flowers about 1.5 cm in diameter on slender pedicels, in 5–8-flowered compact thin-branched compound corymbs; bracts and bractlets oblong-obovate to linear, acute, glandular-serrate, reddish; calyx-tube narrowly obconic, the lobes broad, acuminate, coarsely glandular-serrate, reflexed after anthesis; stamens 10; anthers pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit in few-fruited erect clusters, subglobose, rather broader than high, obscurely angled, gradually narrowed below to the stout petiole, dark red, not pruinose, 1.1–1.2 cm broad; calyx sessile, with a broad shallow cavity and lobes gradually narrowed from broad bases, acute, closely appressed; flesh thin, green, dry and mealy; nutlets 3 or 4, thick, full and rounded at the ends, prominently ridged on the back, with a high rounded ridge, 7 mm long.

A slender shrub 1–2 m high, with erect stems and thin nearly straight branchlets at first light green, dull red-brown and marked by occasional large oblong dark lenticels during their first year, light gray-brown in their second season, and armed with few very slender straight or slightly curved dark red-brown spines 3–4 cm long. Flowers the end of May. Fruit ripens toward the middle of October and mostly falls before the end of the month.

Wood borders. Rare. Between Newport and Newcastle, *W. M. Canby*, September 1899, May and October 1900.

A well marked species in the Pruinosa group, distinguished by the pale yellow anthers of the 10 stamens, by the absence of a calyx-tube from the mature fruit, and by the thinness of the leaves.

INTRICATAE.

Crataegus apposita, n. sp.— Leaves oblong to oval, acute, acuminate or rarely round at the apex, cuneate at the base, glandular-serrate, above the middle usually doubly, with spreading teeth, below with small incurved teeth, or often entire near the base, slightly and irregularly lobed toward the apex, with short acute lobes; as they unfold coated above with soft pale deciduous hairs, at maturity thin but firm in texture, dark yellow-green on the upper surface, paler on the lower surface, 3.5–4 cm long, 2–3 cm wide, with slender 2–4 thin remote primary veins extending obliquely to the points of the lobes; petioles slender, wing-margined above, at first villose, soon glabrous, glandular with small scattered dark red glands, often red toward the base, 1.5–2 cm long; stipules oblong-obovate to linear, conspicuously glandular-serrate, caducous, leaves on vigorous shoots often ovate, acute, broadly cuneate and abruptly narrowed at the base into the wide wing of the short stout petiole, coarsely serrate, deeply 3–5-lobed, 5–6 cm long, 4–6 cm wide, their stipules foliaceous, lunate, coarsely glandular-serrate, 7–10 mm long. Flowers 1.5 cm in diameter on slender pedicels, in few usually 4–7-flowered glandular compound corymbs; bracts and bractlets oblong-obovate to linear, conspicuously glandular-serrate, turning red before falling, caducous; calyx-tube broadly obconic, glabrous, the lobes gradually narrowed from broad bases, acute, glandular-serrate, slightly hairy on the inner face, reflexed after anthesis; stamens 10; anthers pale yellow; styles usually 3. Fruit in drooping clusters, oblong-obovate, full and rounded at the apex, gradually narrowed below into the stout petiole, green until late in the season, then reddish or green more or less blotched with red, or occasionally when fully ripe light red or rarely yellowish-bronze color; calyx-tube elongated, prominent, with a deep narrow cavity, and spreading and appressed lobes coarsely serrate toward the apex; flesh thin,

yellow-green, dry and mealy; nutlets usually 3, broad, obtuse at the ends, rounded and prominently ridged on the back, with a wide rounded ridge, 8–9 mm long.

A thin-stemmed shrub usually 1–2 m high, rarely taller and almost arborescent in habit, with slender spreading branchlets yellow-green tinged with red when they first appear, bright red-brown or purple-brown and marked by few large pale lenticels during their first season, becoming dark gray-brown or reddish-brown the following year, and armed with numerous very slender bright chestnut-brown spines mostly 4–6 cm long. Flowers the middle of May. Fruit ripens about the 10th of October.

Wilmington, May 13, 1899; banks of Brandywine creek above Thompson's Bridge, May 16, and September 23, 1899; north side of Bancroft's Dam, near Wilmington, and Rockford Park, Wilmington, October 9, 1899; banks of Brandywine creek, near Wilmington, May 16, 1900, *W. M. Canby*.

Very closely related to *Crataegus intricata* Lange, a common New England species, this Delaware thorn can be separated from it by the shape of the deeply lobed leaves of vigorous shoots, by the somewhat smaller size, and the color of the fruit, by the elongated tube of the mature calyx, by the more tree-like habit of some individuals, and by its more numerous and more slender spines.

Crataegus nemoralis, n. sp.—Leaves ovate to oval, acute, gradually or abruptly narrowed, slightly divided above the middle into acute lobes coarsely and except toward the base mostly doubly serrate with incurved glandular teeth, tinged with red when they unfold, and covered with long pale caducous hairs on the upper surface, and pale blue-green and sparingly villose on the lower surface, glabrous when the flowers open; at maturity thick and firm, dark green above, paler below, 4–5 cm long, 3–4 cm wide; on leading shoots broader, full and rounded at the base, and often deeply lobed; petioles slender, slightly grooved, at first villose-pubescent, soon glabrous, glandular with small scattered dark persistent glands, 1.5–2 cm long; stipules linear, lobed at the base, villose, coarsely glandular-serrate, early deciduous. Flowers 1.4 cm in diameter, on slender pedicels in compact few-flowered thin-branched glabrous compound corymbs; bracts and bractlets oblanceolate to linear, acuminate, closely glandular-serrate, like the inner bud-scales, often becoming bright red before falling; calyx-tube broadly obconic, glabrous, the lobes broad, acute or acuminate, laciniately glandular-serrate, reflexed

after anthesis; stamens 10; anthers pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit erect, in few-fruited clusters, globose to subglobose or slightly obovate, about 1^{cm} in diameter, dark green until late in the season, becoming dark clear red when fully ripe; calyx prominent with a broad deep cavity, a short tube, and spreading mostly persistent acuminate lobes often serrate above the middle; flesh thin, greenish, dry and mealy; nutlets 3 or 4, thick, acute at the ends, prominently ridged on the back, with a broad often deeply grooved ridge, 7–8^{mm} long.

A tree-like shrub with stems sometimes 3–4^{m} in height and stout zigzag branchlets, light olive-green and glabrous when they first appear, dark purple or reddish-brown and marked by numerous small oblong pale lenticels during their first season, and dark gray-brown in their second year and armed with many slender chestnut-brown or purple spines usually pointed toward the base of the branch and 5–6^{cm} long. Flowers the middle of May. Fruit ripens in October and falls before the leaves.

Common along woody borders, often in rocky soil. Rockford Park, Wilmington, October 1899, May and October 1900 and 1901, *W. M. Canby*.

This thorn, which is common in northern Delaware, is closely related to *Crataegus Boyntoni* Beadle, of the southern Appalachian region, differing from that species only in its smaller flowers on more slender pedicels, in its fewer-flowered corymbs, in its rather thinner leaves, and in the different color and size of the fruit which is inclined to be short-oblong or obovate.

Crataegus cuprea, n. sp.—Glabrous. Leaves ovate to rhombic, acute or acuminate at the apex, gradually or abruptly narrowed and concave cuneate or full and rounded, or on vigorous shoots sometimes slightly cordate at the entire glandular base, sharply and often doubly serrate above with nearly straight gland-tipped teeth and divided into 2–4 pairs of short acute lateral lobes; nearly fully grown, membranceous and pale green when the flowers open, at maturity thin but firm in texture, dark yellow-green on the upper surface, pale on the lower surface, 5–7^{cm} long, 3.5–5.5^{cm} wide, with prominent midribs and few remote primary veins extending to the points of the lobes; petioles slender, usually wing-margined above, glandular with stipitate dark red glands often deciduous before the autumn, 1.5–2.5^{cm} long. Flowers about 1.2^{cm} in diameter, on short often glandular pedicels, in 3–5-flowered compact compound thin-branched corymbs; bracts

and bractlets conspicuous, oblong-obovate, acute, or rounded at the apex, coarsely glandular-serrate, tinged with red; calyx-tube broadly obconic, the lobes elongated, abruptly narrowed from broad bases, enlarged, foliaceous and glandular-laciniate above the middle, mostly entirely below, reflexed after anthesis; stamens 10; anthers pale yellow; styles 3 or 4. Fruit subglobose to short-oblong, often somewhat narrowed at the base, when fully grown at first green, then russet or copper color, and at maturity sometimes dull red, marked by few large dark dots, 1^{cm} long, 8 or 9^{mm} wide; calyx prominent, with a broad shallow cavity and spreading lobes coarsely serrate above the middle and often wanting from the ripe fruit; flesh thin, dry, yellow-green; nutlets 3 or 4, thick, rounded at the ends, prominently ridged on the broad rounded back, 7–8^{mm} long.

A low-branched stoloniferous shrub sometimes 2^{m} high, with slender branchlets, green tinged with red when they first appear, bright red-brown, lustrous and marked by numerous large oblong pale lenticels during their first season, and dull reddish-brown in their second year, and sparingly armed with straight stout bright red-brown lustrous spines 3–4^{cm} long, or unarmed. Flowers about the 20th of May. Fruit ripens early in October.

Vacant lots, Wilmington, Delaware, September and October 1899, May 1900, *W. M. Canby*.

PUNCTATAE.

CRATAEGUS PUNCTATA Jacquin.—Banks of Brandywine creek below Smith's Bridge, May 1869; banks of White Clay creek below Stanton, 1902, *W. M. Canby*.

MOLLES.

Crataegus Tatnalliana, n. sp.—Leaves ovate to oval, acute, broadly cuneate, or on leading shoots rounded or rarely cordate at the entire base, divided above into short acute lobes and coarsely and usually doubly glandular-serrate; as they unfold light green and covered above with short lustrous white hairs, rather paler below and villose along the midribs and primary veins; at maturity membranaceous, dark yellow-green and scabrate on the upper surface, paler and glabrous on the lower surface with the exception of a few scattered hairs on the slender yellow midribs and 5 or 6 pairs of thin primary veins extending

to the points of the lobes, 8–10^{cm} long, 5.5–6^{cm} wide; petioles slender, at first villose-pubescent, soon glabrous or rarely puberulous at maturity, 2.5–3^{cm} long; stipules spathulate, acute, conspicuously glandular-serrate, caducous, or on vigorous shoots foliaceous, full and rounded below, acuminate at the apex. Flowers 2^{cm} in diameter, in compact ultimately lax slender-branched many-flowered compound corymbs; bracts and bractlets foliaceous, oblong-obovate, acute or short-pointed at the apex, coarsely serrate, their teeth tipped with large bright red glands; calyx-tube broadly obconic, thickly coated like the short slender pedicels with long white hairs, the lobes acuminate, serrate, with elongated teeth tipped with red glands, dark green, slightly puberulous particularly along the lower side of the prominent midvein; stamens 10; anthers large, white; styles 3 or 4, surrounded at the base by a broad ring of white tomentum. Fruit in few-fruited drooping puberulous corymbs, globose, obovate or rarely oblong, full and rounded at the ends, bright orange-red, marked by large pale dots, puberulous toward the base, 1.5–2^{cm} long, 1–2^{cm} wide; calyx cavity broad and deep, the lobes gradually narrowed from broad bases, acuminate, coarsely serrate usually only above the middle, puberulous, bright red on the upper side toward the base, closely appressed or rarely erect and incurved; flesh thick, yellow, dry and mealy; nutlets 3 or 4, thin, acute at the narrow ends, very irregularly ridged on the rounded back, 7–8^{mm} long.

A shrub 4 or 5^{m} high, with numerous stout stems forming a broad head, and thick slightly zigzag branchlets at first villose, soon glabrous, dark red-brown, lustrous and marked by numerous large oblong white dots during their first season, becoming ashy gray and lustrous during their second year and ultimately darker, and armed with stout straight or slightly curved bright chestnut-brown shining spines 4–5^{cm} long. Flowers during the first week of May. Fruit ripens from the middle to the end of August and soon falls.

Hedge rows and wood borders. Near Newport, August 1899, May and August 1900; between Newport and Newcastle, September 1899 and 1900, *W. M. Canby*.

Well distinguished from previously described species of the Mollis group by the peculiar hairs which cover the calyx and pedicels of the flower, the large foliaceous bracts and bractlets of the corymb, by the foliaceous calyx-

lobes, and by its habit. This common Delaware species may be fittingly associated in its name with Edward Tatnall, the author of the *Catalogue of the Phaenogameus and Filicoid Plants of Newcastle County, Delaware.*

LOBULATAE.

CRATAEGUS ARCTUATA Ashe, Ann. Carnegie Mus. 1:387. May 1902.—I doubtfully refer to this species, on the strength of the published characters, a common thorn of Newcastle county, Delaware, and of Bucks county, Pennsylvania. *Crataegus arctuata* is a large shrub or small tree with broad ovate acute membranaceous leaves divided into numerous short acute lateral lobes, flowers in wide many-flowered villose corymbs with 5–7 stamens and red anthers, and short-oblong subglobose fruit ripening toward the end of August and soon falling.

Hedges near Wilmington, May and September 1899; near Newport, May and August 1900; hedges near Wilmington, May 1900; fields south of Eden Park, May and October 1900, *W. M. Canby;* Pennsylvania, Sellersville, Bucks county, May, September and October 1901, *C. D. Fretz.*

The name *arctuata* was used in 1886 by Gandoger in his *Flora Europae* for one of his proposed species of his genus Oxyacantha (*Crataegus Oxyacantha* Linnaeus), but as Gandoger's names can hardly be taken up by botanists it does not now seem worth while to make a new name for Mr. Ashe's species.

TENUIFOLIAE.

CRATAEGUS TENELLA Ashe, Ann. Carnegie Mus. 1:388. May 1902.—Although I have been unable to see an authenticated specimen of the *Crataegus tenella* of Ashe described from material gathered in Delaware county, Pennsylvania, I refer provisionally, at least, to that species the common thin-leaved shrubby thorn of eastern Pennsylvania and Newcastle county, Delaware, with 5–7 stamens, pink anthers, and oblong or rarely pear-shaped bright scarlet lustrous fruits, with soft pulpy flesh, ripening early in September and often remaining on the branches until October.

Du Pont woods near Wilmington, September 7, 1899; border of marsh between Newport and Stanton, September 9, 1899; Newport, May 14, 1899; banks of Brandywine creek below Smith Bridge, May 16, 1899, *W. M. Canby;* Pennsylvania, Delaware county, woods below Castle Rock, May and September 1901; near Upper Darby, October 1901, May 1902; hill south of Castle Rock, May 1902, *B. H. Smith;* Bucks county, near Sellersville, September 1899, May and September 1901; near Telford, June 1899, *C. D. Fretz.*

Crataegus stolonifera, n. sp.—Leaves ovate-oblong, acuminate, rounded, truncate or sometimes slightly cordate at the broad base, more or less deeply divided into four or five pairs of acute or acuminate lobes, coarsely and often doubly serrate, with straight or incurved glandular teeth; as they unfold suffused with red and villose above, with long pale caducous hairs; at maturity thin but firm in texture, glabrous, dark yellow-green on the upper surface, pale on the lower surface, 4.5–6 cm long, 3–4 cm wide, with slender midribs slightly impressed above and 4 or 5 pairs of remote primary veins extending to the points of the lobes; petioles slender, slightly grooved, at first glandular, with numerous small dark deciduous glands, often red below the middle, 1.5–2 cm long; stipules linear, acuminate, finely serrate, bright red, caducous. Flowers 1.5 cm in diameter, in compact mostly 5–10-flowered thin-branched glabrous compound corymbs; bracts and bractlets oblong-obovate to linear, acuminate, finely glandular-serrate, bright red, caducous; calyx-tube narrowly obconic, the lobes acuminate, entire or slightly serrate toward the apex, often red toward the base, reflexed after anthesis; stamens 5–7; anthers small, dark red tinged with purple; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit in few-fruited drooping clusters, usually on short pedicels, short-oblong to subglobose, scarlet, lustrous, 1–1.1 cm long; calyx cavity broad and shallow, the lobes gradually narrowed from broad bases, acuminate, mostly entire or sparingly serrate, red on the upper side toward the base, closely appressed; flesh yellow, thick and succulent; nutlets 3 or 4, thick, narrow and acute at the ends, prominently ridged on the back, with a thin high ridge, 7–8 mm long.

A shrub 2–3 m tall, with numerous stems spreading into broad thickets and slender slightly zigzag branchlets olive-green tinged with red when they first appear, dull red-brown during their first and olive-green during their second year, and armed with numerous stout slightly grooved bright chestnut-brown spines 3–5 cm long. Flowers from the 10th to the middle of May. Fruit ripens early in September and soon falls.

Rocky hillsides and the borders of swamps in rich moist soil. Between Newport and Stanton, May and September 1899; Clayton street and Delaware avenue, Wilmington, May and September 1899 and 1900, *W. M. Canby;*

Pennsylvania, meadows near Sellersville, Bucks county, May and October 1901, September 1902, *C. D. Fretz.*

In the shape, texture and color of the leaves this handsome species resembles the New England *Crataegus pastorum* Sargent, but differs from it in its smaller number of stamens and in its much larger subglobose earlier ripening fruit, and in habit.

PARVIFLORAE.

CRATAEGUS UNIFLORA Moench.—Not common.

CRATAEGUS CORDATA Aiton and the Old World CRATAEGUS OXYACANTHA Linnaeus are sparingly naturalized in Newcastle county.

ARNOLD ARBORETUM,
Jamaica Plain, Mass.

THE RAVENELIAS OF THE UNITED STATES AND MEXICO.

WILLIAM H. LONG, JR.

(WITH PLATES II AND III)

THE writer originally intended to include in this paper only the Texan species, but as the study advanced it became evident that many Mexican species would be found in Texas, probably all of them when the fungal flora of the extreme southern and southwestern section of the state is collected and studied; while in the eastern and northeastern counties the species of the southern Atlantic states would probably be found; so it was thought best to include in the present paper all known Ravenelias from the United States and Mexico.

The genus seems to be mainly tropical and subtropical, only two species being found above latitude 38°, viz., *R. opaca* and *R. epiphylla*, the latter being the most widely distributed subtropical species known, extending as far north as New York, westward to the Mississippi, and southward to Florida. The known species are distributed as follows: United States 11, Mexico 15, Central and South America 21, West Indies 1, South Africa 12, Ceylon 5, and Japan 1.

The Ravenelias are among the most natural and marked groups of all the Uredineae. So far as known they are confined entirely to the Leguminosae as to host, with two exceptions, viz., *R. appendiculata* and *R. pygmaea*, found on Phyllanthus. Most of the species on the Leguminosae are parasitic on the two suborders Caesalpinieae and Mimoseae.

The genus Ravenelia was founded by Berkeley, with *R. indica* and *R. glandulosa* as its first species. At that time, and for some years afterwards, the exact status of the genus was not known, as the general morphology of the plant and the germination of the teleutospores had not been studied. Later Parker[1] studied

[1] On the morphology of *Ravenelia glanduliformis*. Proc. Amer. Acad. 22: 205–217. 1886.

the morphology of one species, and Cunningham[2] worked on the life histories of two species. Duggar[3] investigated the germination of the teleutospores. In 1894 Dietel[4] published his excellent monograph of the genus. This included all the Ravenelias then known and gave a brief résumé of previous work, together with a rather full discussion of the characters of the various species, followed by systematic descriptions and plates to illustrate the various species. Since then many new species (about fifteen) have been described by various authors, most of them from the Americas. Much light was thrown on the general life-history, morphology, etc., by these investigations, and the true status of the genus was fully determined, all of its characters undoubtedly placing it with the Uredineae. Much careful work yet remains to be done, as all that is known of most of the species is a brief systematic description of the dried plant.

The writer is under many obligations for specimens, etc., to Mr. E. W. D. Holway, Dr. P. Sydow, Dr. P. Hennings, Dr. P. Dietel, Dr. W. G. Farlow, Professor E. O. Wooton, Mr. S. B. Parish, Mr. Elam Bartholomew, Dr. D. Griffiths, Shaw Botanical Gardens, New York Botanical Gardens, Dr. J. C. Arthur, and the U. S. Dept. of Agriculture; also to Professor George F. Atkinson for his aid and advice throughout the prosecution of this work.

All drawings were made with the aid of an Abbé camera lucida from material that had been boiled in lactic acid to restore the spores to their natural size and shape and bring out details that would not otherwise be noted. In some instances only a small quantity of material of a given species was available. In such a case the question arose how best to utilize this to show all the essential characters. The method pursued was first to mount a bit in distilled water and allow the water to evaporate. In this condition all the minute surface markings of the spores are more plainly seen; but this preparation would not show the germ pores and would usually burst the cysts. Hence a second mount was

[2] Notes on the life history of *Ravenelia sessilis* B. and *Ravenelia stictica* B. and Br. Scientific Mem. of Medical Officers of the Army of India, 1889.

[3] Germination of the teleutospores of *Ravenelia cassiaecola*. BOT. GAZ. 17: 144–148. 1892.

[4] Die Gattung Ravenelia. Hedwigia 33: 22–69, 367–371. 1894.

found necessary, prepared as follows: A mixture of equal parts of 100 per cent. glycerin and 80 per cent. alcohol was made, and a glass slide was used on which a cell of white zinc had been made. It was found necessary to make the cells two layers thick in order to get the proper depth, putting on as much zinc each time as would stay without spreading too much; an interval of one to two hours between the putting on of the two layers is required. The slide was laid aside until the cell became dry and hard. In the center of this cell a scant drop of the glycerin and alcohol mixture was put; into this the spores, etc., were put; then a drop of 50 per cent. lactic acid was added and the slide heated over an alcohol lamp until the liquid came to a boil. In some cases it is necessary to boil it for a short time to make the germ pores show plainly. Care had to be taken not to boil so long as to burst the cysts, and yet to boil until the germ pores were visible; usually bringing the mixture to a boil accomplished the desired result. The mixture of alcohol and glycerin as given above prevents the bursting of the cysts, which usually happens in a water mount, while the acid makes the germ pores visible. After the preparation had cooled a cover glass was put on and sealed with white zinc. This makes a neat permanent mount, ready for instant use at any time, and shows practically all the desired details.

To ascertain whether the sori are subepidermal or subcuticular, microtome sections should be made. Most of the specimens will be dry and must be softened before they can be imbedded. A good method for softening the tissues is to place them in a mixture of equal parts of 65 per cent. alcohol and 100 per cent. glycerin; then heat this in the paraffin oven for twenty-four to forty-eight hours, at the end of which time the tissues will usually be soft and pliable; then wash in 65 per cent. alcohol for six hours; then run up and into paraffin in the usual manner. Bismarck brown or methyl blue makes a good stain for such preparations where the main object is to see the position of the sori. The cysts would often come through the entire process and show up beautifully in the Canada balsam mount.

The boiling in lactic acid is desirable for several reasons;

in addition to its bringing out the germ pores it swells the spores to their normal shape and size; drives out the air and makes them more transparent; by scattering the spores makes visible any uredospores or paraphyses that would otherwise be overlooked. By this means the uredospores of several species were found, of which hitherto only the teleutospore stage had been known.

Sometimes it is necessary to make a fourth preparation to see whether the teleutospores are all one-celled, or some two-celled; this will often be shown in the lactic acid mount where some of the teleutospore heads will be broken up; but in case this does not happen, it becomes necessary to macerate the material for twelve to twenty-four hours in a weak solution of caustic potash or even to boil it in this solution for a few minutes, when by pressure on the cover glass the heads will fall apart and the interior structure can be seen.

If permanent mounts are not desired, the cell feature can be omitted and the mount made on the slide direct. Usually free-hand sections of the softened specimen will show the position of the sori in the leaf, and this can be done where a sufficient quantity of material is available; but where only a bit, and that of a type or rare species is at hand, it is best to use the microtome.

A study of the life history of the various species has not been attempted in this article. One species (*R. Holwayi*) was found whose aecidial stage differs from the type in that it is without a pseudoperidium. This species is placed in a new genus (Neoravenelia), distinguished from Ravenelia by its caeoma type of aecidia. The deep-seated character of the aecidiosori of this species is in marked contrast to the very shallow sori of the uredospores and teleutospores, which are usually between the cuticle and the epidermal cells or just beneath the epidermis. As the life history of the various species becomes better known, others in all probability will be found to have a caeoma type of aecidia, and will have to be transferred to Neoravenelia.

The genus naturally falls into two sections, according to the number of cells in the teleutospores. The first section (Rave-

nelia) includes all species in which all the teleutospores in a head are one-celled; the second section (Pleoravenelia) includes all species in which the inner teleutospores of a head are two-celled. As a matter of convenience it seems desirable to recognize these two sections as distinct genera.

KEY TO GENERA.

All teleutospores in a head one-celled; aecidia when present with a well developed pseudoperidium - - - - - - *Ravenelia*
Inner teleutospores in a head two-celled; aecidia as in Ravenelia - - - - - - - - - - - - *Pleoravenelia*
All teleutospores in a head one-celled; aecidia without a pseudoperidium - - - - - - - - - - - *Neoravenelia*

RAVENELIA Berk.

BERKLEY, Gardeners' Chronicle 10: 132. 1853.

PARKER, The Morphology of *Ravenelia glanduliformis*. Proc. Amer. Acad. 22: 205–217. 1886.

COOKE, The genus Ravenelia. Jour. Roy. Micr. Soc. 3: 384. 1880.

DUGGAR, Germination of the teleutospores of *Ravenelia cassiaecola*. BOT. GAZ. 17: 144–148. 1892.

DIETEL, Die Gattung Ravenelia. Hedwigia 33: 22–69, 367–371. 1894; Engler and Prantl. Nat. Pflanz. 11: 73–75. 1897–1901.

Spermogonia formed between the cuticle and the epidermal cells, hemispherical. Aecidia with a well developed pseudoperidium. Uredospores borne singly on short stalks, with germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads, formed of several or many cells; all teleutospores in a head one-celled; attached to the under side of the heads are several to many hyaline cells or cysts; pedicel of the head composed of several hyphae, which are either united into a compound stipe or separate.

KEY TO SPECIES.

1. Teleutospore heads smooth - - - - - - - - - 2
   Teleutospore heads rough, spinous, warty, etc. - - - - - 8
2. Uredospore germ pores many, scattered - - - - - 3
   Uredospore germ pores equatorial in one row - - - - 5
   Uredospore germ pores in two rows - - - - - - 6
   Uredospores unknown - - - - - - - - - 7
3. Sori sub-cuticular; cysts pendent - - - - - - - 4

4. Cysts peripheral; paraphyses many, clavate-capitate - - *R. texana*
   Cysts beneath entire head; paraphyses few, hypha-like - *R. Longiana*
   Cysts beneath entire head; paraphyses none; pedicel stout, fulvous - - - - - - - - - - - *R. indica*
5. Sori sub-epidermal germ pores 4; cysts pendent many "*R. Holwayi.*"
6. Uredospores brown, with a row of 4 germ pores on either side of equator - - - - - - - - - - *R. siliquae*
   Uredospores fulvous, base hyaline to semi-hyaline, 4 germ pores in equator and 4 in a row near base - - - - *R. versatilis*
7. Sori sub-cuticular; heads chestnut brown - - *R. Farlowiana*
   Sori sub-epidermal; heads black, opaque - - - - - *R. opaca*
8. Uredospore germ pores many, scattered - - - - - - 9
   Uredospore germ pores 4, equatorial - - - - - - 12
   Uredospore germ pores 8, in two rows on either side of equator - - - - - - - - - - - *R. siliquae*
9. Sori sub-cuticular; cysts peripheral - - - - - - - 10
   Sori sub-cuticular; cysts not peripheral - - - - - - - 11
   Sori sub-epidermal; cysts coherent; III heads densely warty. *R. verrucosa*
10. Cysts pendent; heads minutely verrucose - - - *R. expansa*
    Cysts pendent; heads several with long (5–8 μ) brown papillae on each spore - - - - - - - *R. mimosae-sensitivae*
11. Stipe long, persistent, fulvous; papillae few, scattered - *R. cassiaecola*
    Stipe short, hyaline; papillae few, scattered - - - *R. mesillana*
    Stipe short, hyaline; III heads with several short papillae to each spore - - - - - - - - - *R. fragrans*
    Stipe short, hyaline; III with one (2–7 μ) papilla to each spore. *R. spinulosa*
12. Sori sub-epidermal; each spore of III heads armed with a stout appendage which is branched at apex - - *R. appendiculata*
    Sori sub-epidermal; each spore of III heads armed with a curved hyaline spine (1–6 μ) - - - - - *R. arizonicā*
    Sori sub-cuticular; cysts not pendent, peripheral; uredospores 18–20 by 22–25 μ - - - - - - - *R. mexicana*
    Sori sub-cuticular; cysts pendent, peripheral; uredospores 15–18 by 35–40 μ - - - - - - - - *R. leucaenae*

RAVENELIA TEXANA Ell. and Galw., Jour. Mycol. **6**: 2. 83. 1890; Jennings, Bull. Tex. Agr. Exp. Sta. **9**: 1890.—*Fig. 1.*

Ravenelia texensis Dietel, Hedwigia **34**: 42–43, 63–64. 1895; Saccardo Syll. Fung. **11**: 210. 1895.

Sori breaking forth between the cuticle and the epidermal cells on both sides of the leaves, and sparingly on the leaf stems,

[5] See *Neoravenelia Holwayi.*

small. Uredosori not present in material examined; uredospores oval to spheroid, light brown, spinulose, 13–20 by 16–20 μ, germ pores many, scattered; paraphyses hyaline to fulvous, clavate to capitate, 50–70 μ long, 10–20 μ thick; heads fulvous. Teleutospore heads dark brown, smooth, irregularly orbicular, 60–70 by 20–35 μ thick; 5–6 spores in cross-section, each 16–20 by 30 μ, tops dark brown; cysts oblong to ovate, hyaline, pendent, peripheral, swelling and bursting in water; pedicel hyaline, short.

On Desmanthus or Cassia: College Station, Texas, 1889. Leg. *Brunk* and *Jennings*.

RAVENELIA LONGIANA Syd., Hedwigia **40**: 128. 1901.—*Fig. 2.*

Sori breaking forth between the cuticle and the epidermal cells; on both sides of the leaves. Uredosori cinnamon-brown, orbicular, 0.5–1 mm in diameter, often confluent over wide areas, mainly on the under side of the leaves; uredospores obovate, oval or spheroid, spinulose, light brown, 20–33 by 23–26 μ; germ pores many, scattered; paraphyses present in the uredosori; few, semi-hyaline, hypha-like, walls much thickened. Teleutosori large, black, orbicular, 1–2 mm in diameter, on both sides of the leaves; teleutospore heads chestnut-brown, smooth, irregularly orbicular, 75–90 by 25–33 μ thick; 6–8 spores in cross section; cysts hyaline, spheroid to pyriform, beneath entire head, crowded, diameter about 16 μ; pedicel hyaline, compound, short.

On *Cassia Roemeriana*: Austin, Texas, Nov. 15, 1897 (type material for III spores); Aug. 24, 1901, no. 1019 (type for II sori). The type material for this species had no uredosori on the leaves, but a few uredospores were intermixed with the teleutospores. In August 1901, the writer collected the uredosori for the first time; the under side of the leaves of the host was nearly covered with the sori, while the upper surface was comparatively free.

RAVENELIA INDICA Berkeley, Gard. Chron. **10**: 132. 1853. Cooke, Jour. Roy. Micr. Soc. **3**: 385. 1889; Saccardo, Syll. Fung. **7**: 772–773. 1888; Dietel, Hedwigia, **33**: 51–52, 60. 1894; Holway, BOT. GAZ. **31**: 336. 1901.—*Fig. 4.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori on both sides of the leaves, often irregularly grouped around a central sorus, cinnamon-brown; uredospores ovate to globose, spinulose, pale yellow, 13–17 by 17–20 μ; germ pores many, scattered; paraphyses none. Teleutosori

on the leaf stems and on the branches, forming somewhat swollen places of 4–6 mm in diameter, chestnut-brown; teleutospore heads orbicular, smooth, light brown, 60–85 by 33–40 μ thick; 4–6 spores in cross section, each 16–22 μ broad; cysts firm, persistent, flask-shaped, hyaline, 15–18 μ in diameter, hanging in a cluster around the pedicel, beneath the entire head; pedicel stout, persistent, compound, fulvous, 95–150 by 20–25 μ.

On *Cassia absus:* Tequila, Mexico, Sept. 29, 1893. Leg. *Pringle.*

Ravenelia siliquae, n. sp.— *Fig. 7.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori orbicular, large, 1–4 mm in diameter, cinnamon-brown, prominently surrounded by the ruptured cuticle, scattered or more or less confluent; uredospores fulvous, epispore densely verrucose, oblong-oval to ovate-fusiform, 13–17 by 20–33 μ, usual size 16 by 30 μ; germ pores 8, in two rows of 4 each, one row on either side of the equatorial zone; paraphyses very rare, hyaline or slightly fulvous at the apex, clavate, 43 by 7 μ.

On pods of *Acacia farnesiana:* Etla, Oaxaca, Mexico, Oct. 25, 1899, no. 3841, *Holway.* Mr. Holway writes that this species was found only on the pods, the leaves being free from the rust. The peculiar position of the germ pores of the uredospores is such a marked character that the writer did not hesitate to establish a new species, as no other known Ravenelia has this character. No teleutospores were present in the material examined.

RAVENELIA VERSATILIS (Peck) Dietel, Hedwigia **33**: 38–42, 64, 368–369. 1894; Saccardo, Syll. Fung. **11**: 210–211. 1895.— *Fig. 3.*

Uromyces versatilis Peck, BOT. GAZ. **7**: 56. 1882; Saccardo, Syll. Fung. **7**: 582–583. 1888.

Ravenelia decidua (Pk.) Holway, Dietel in Hedwigia **33**: 370. 1894; Saccardo, Syll. Fung. **11**: 211. 1895.

Uromyces deciduus Peck, Reg. Rept. **45**: 25. 1891.

Sori breaking forth between the cuticle and the epidermal cells, on both sides of the leaves. Uredosori small, ochreous, thickly covering the leaves and often the leaf stems and branches; upper half of spores brown and somewhat thickened at apex, with spinules less prominent than those of the lower part; lower half fulvous to sub-hyaline, rugose-echinulate; elliptical to ellip-

tical-ovate, 27–33 by 14–17 μ; germ pores 8 in two rows, one row of 4 germ pores in the equator, the other row near the base of the spore; paraphyses numerous, light yellow to semi-hyaline, clavate to capitate; pedicel hyaline, 50–60 μ long; heads 13–20 μ in diameter, very variable in shape. Teleutosori dark brown, on both sides of the leaves, small, 1 mm or less in diameter, oval to orbicular; teleutospore heads brown, usually smooth, but margin of some of the fully mature spores sometimes faintly verrucose, orbicular to oval, 83–100 μ in diameter; 6–8 spores in cross section, marginal spores 10–12, spores 40–45 by 16–18 μ, with apex brown for 4–5 μ; cysts hyaline, peripheral, oblong-ovate, few, 24–30 μ, swelling and finally bursting in water; pedicel compound, short, slightly fulvous, deciduous.

On *Acacia Greggii:* Gillespie co., Texas, *Jermy* 557 (U. S. Dept. Agr.); Tucson, Arizona, Aug. 1892, *J. W. Toumey*; San Bernardino, Cal., June 4, 1894, *Parish* 3377; Mescal mts., Arizona, May 24, 1890, *M. E. Jones.*

This is one of the very widely distributed Ravenelias as the above citations show. It is also a very marked and easily recognized species, as its uredospores are very characteristic, having two rows of germ pores, one in the equator and the other near the base of the spore, the lower half usually being hyaline or nearly so, and when boiled in lactic acid the lower half swells up and the outer part of the epispore appears gelatinous, giving the entire spore somewhat the appearance of an acorn in its cup, the upper half representing the acorn and the lower the cup.

In all the material examined except the Texan specimen, only uredosori were present, with an occasional teleutospore; the Texan specimen on the other hand was teleutospore material with only a few uredospores intermixed. A sufficient number were present, however, to fully identify the plant and to show all the peculiar characters of the typical uredospores of *R. versatilis.* The Texan plant was reported on *Acacia filicina* Willd., which proved on comparison with authentic specimens to be not *A. filicina* but *A. Greggii.* This comparison was made by the writer at the Missouri Botanic Garden, St. Louis, with Jermy's original collection from near San Antonio, Texas. Even the plant in the herbarium was infected with the rust. The species heretofore called *R. decidua* (Peck) Holw. proved on careful comparison to be in every respect identical with *R. versatilis* (Pk.) Diet. It is reported on all specimens examined as being on *Prosopis pubescens,* but a comparison of authentic specimens of this species with the host proved the previous determinations to be erroneous, and the host to be *Acacia Greggii.* Type material of *R. decidua* was examined and compared with authentic specimens of *R. versatilis,* with the above results both as to hosts and parasites.

RAVENELIA FARLOWIANA Dietel, Hedwigia **33**: 369. 1894; Saccardo, Syll. Fung. **11**: 211. 1895.—*Fig. 6.*

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper surface of the leaves and sparingly on the leaf stems. Uredosori and uredospores not present. Teleutosori orbicular, large, 4–5 mm in diameter, dark brown, when old with heads densely compacted into a crust-like layer, when young with a central sorus surrounded by a circle of spores, usually solitary; paraphyses none. Spermogonia present, chestnut-brown, about 100 μ in diameter, subcuticular. Teleutospore heads very irregular in shape and in size, chestnut-brown, usually smooth but an occasional head with small warts on the margin, 50–106 by 40 μ thick, usual size 75–95 μ; spores 5–8 in cross section, very irregular in shape and size; cysts hyaline, peripheral, oblong ovate, with bases closely appressed to under side of heads, swelling and bursting in water; pedicel short, hyaline, deciduous.

On *Acacia anisophylla* and *A. crassifolia:* Mexico, *Pringle.* Specimens examined from herb. of Dr. Farlow.

RAVENELIA OPACA (Seym. and Earle) Dietel, Hedwigia **34**: 291. 815; Saccardo, Syll. Fung. **14**: 363. 1899.—*Fig. 5.*

Ravenelia indica forma *opaca* Seym. and Earle, Econ. Fungi no. 203.

Sori subepidermal, scattered or solitary on both sides of the leaves but mainly on the upper surfaces. Uredosori and uredospores not present. Teleutosori black, shining, large, 1–2 mm in diameter; teleutospore heads black, opaque, orbicular, smooth, 80–120 μ in diameter; 5–6 spores in cross section, spores 20–26 by 33 μ, apex intensely black-brown for 7–10 μ; cysts globose, hyaline, pendent around the pedicel, swelling and bursting in water. Pedicel long, compound hyaline.

On *Gleditschia triacanthus:* Clear Creek, Union co., Ill., *F. S. Earle,* Aug. 13, 1890.

RAVENELIA VERRUCOSA Cke. and Ell., Jour. Mycol. **3**: 83. 1887; Grevillea **15**: 112. 1887; Saccardo, Syll. Fung. **7**: 772. 1888; Dietel, Hedwigia **33**: 41–42, 66. 1894.—*Fig. 9.*

Sori subepidermal, on both sides of the leaves but mainly on the upper surface. Uredospores intermixed with the teleutospores, brown, spinulous, oval to globose, 15–18 by 17–20 μ; germ pores many, scattered; paraphyses many, cylindrical, hypha-like,

chestnut-brown, 45–60 by 7 μ, bases hyaline. Teleutosori black, 0.5–1 mm in diameter, more or less covering the surface of the leaves; teleutospore heads chestnut-brown, opaque, irregularly orbicular, 75–100 by 35–40 μ; 4–8 spores in cross section, spores with many short hyaline papillae to each spore; cysts coherent and decurrent into the hyaline pedicel, peripheral; pedicel short, hyaline, deciduous.

On *Leucaena lanceolata:* Watson no. 6, *Dr. E. Palmer*, 1886. The host was determined by Dr. J. N. Rose, U. S. National Museum.

RAVENELIA EXPANSA Diet. and Holw., BOT. GAZ. **23**: 35. 1887; Saccardo, Syll. Fung. **14**: 364. 1899.—*Fig. 10.*

Sori breaking forth between the cuticle and the epidermal cells, on both sides of the leaves, in large pallid spots which are specially prominent on the under side of the leaves. Uredosori rare, ochraceous, small; uredospores fulvous, spinulose, globose to subglobose, 17–20 by 20 μ; germ pores many, scattered; paraphyses clavate, heads fulvous, 13–16 by 26 μ; pedicel hyaline, about length of head or often shorter. Mature teleutosori chestnut-brown, large, up to 2 mm in diameter, surrounded by the ruptured cuticle; teleutospore heads orbicular, verrucose, light brown, 70–90 by 35–40 μ thick; 5–7 spores in cross section, each crowned with several short, hyaline warts; cysts hyaline, pendent, oblong ovate, peripheral, 7–10, easily swelling and bursting in water; pedicel hyaline, short, compound, deciduous.

On *Acacia tequilina* Wats.: Guadalajara, Mexico, Oct. 13, 1896 (type), *Holway.*

RAVENELIA MIMOSAE-SENSITIVAE P. Henn., Hedwigia **35**: 246. 1896.—*Fig. 11.*

Sori breaking forth between the cuticle and the epidermis, on both sides of the leaves, thickly distributed over the leaf surface. Uredosori cinnamon color, often in a circle around a central sorus; uredospores light brown, densely spinulose, ovate to spheroid, 20–22 by 23 μ; germ pores many, scattered; paraphyses broadly clavate to subcapitate, 13–20 by 50–60 μ; heads fulvous, pedicel and base of head hyaline. Teleutosori small, scattered, black; teleutospore heads orbicular to oval, black-brown, 65–80 by 33 μ thick; spores 4–6 in cross section, each crowned with several long (5–8 μ) brown papillae, apex somewhat

thickened for 5–6 μ, spores 33–35 by 16–20 μ; cysts hyaline, ovate to spheroid, about 20 μ in diameter, peripheral, 6–10; pedicel short, hyaline, deciduous.

On *Mimosa albida:* Cuernavaca, Mexico, Sept. 24 and 29, 1899, *Holway*. Through the kindness of Dr. Hennings the writer was enabled to compare the Mexican form with type material from South America, and the two proved to be the same species.

RAVENELIA CASSIAECOLA Atkinson, BOT. GAZ. **16**: 313. 1891; Dietel, Hedwigia **33**: 50–51, 60–61. 1894; Duggar, BOT. GAZ. **17**: 144–148. 1892; Saccardo, Syll. Fung. **11**: 212. 1895; Atkinson, Bull. Cornell Univ. Science **3**: 20. 1897; Underwood and Earle, Bull. 80, Ala. Agr. Exp. Sta. 217–218. 1897.—*Fig. 12.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori mainly on the leaves, on both sides, small, 1 mm or less, cinnamon colored; uredospores broadly ovate to globose, fulvous or hyaline, minutely echinulate, 14–17 by 16–18 μ; germ pores many, scattered; paraphyses none. Teleutosori on the stems, black-brown, large, often confluent for several centimeters; teleutospore heads fulvous to chestnut-brown, 30–100 μ, usual size 60–80 μ; 4–6 spores in a cross section, usually with a short hyaline point to each spore; cysts hyaline, firm, globose, 14–18 μ in diameter, pendent, beneath the entire head; pedicel compound, persistent, fulvous, 60–110 μ long.

On *Cassia nictitans:* Auburn, Ala., 1891, *Atkinson*, also 1893, *Duggar;* Starkville, Miss., Sept. 19, 1892, *Ellis* and *Everhart*, N. A. F. 2d series, no. 2880, also Sept. 19, 1891, *Seymour* and *Earle*, E. C. Fung. Suppl. no. 325.

RAVENELIA MESILLANA Ell. and Barth., Bull. Torr. Bot. Club **25**: 508. 1898; Saccardo, Syll. Fung. **16**: 323. 1902.—*Fig. 13.*

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper surface of the leaves. Uredosori not present in material examined, but uredospores intermixed with teleutospores; uredospores light brown, broadly oval to globose, spinulose, 20–23 by 17–20 μ; germ pores many, scattered; paraphyses none. Teleutosori orbicular, crowded and often confluent, more or less covering the upper surface of the leaves, black-brown; teleutospore heads chestnut-brown, irregularly orbicular, an occasional head with one or two short papillae on

its surface, 50–75 by 30–35 μ thick; 4–6 spores in cross section; cysts hyaline, globose, many, beneath the entire head, 15–18 μ in diameter; pedicel compound, short, hyaline.

On *Cassia bauhinioides:* Mesilla Park, N. M., Oct. 1897, *E. O. Wooton* (type ex. Herb. E. Bartholomew); same station and collector, October 1895 (ex. Herb. A. & M. College, N. M.).

Ravenelia fragrans, n. sp.—*Fig. 14.*

Sori breaking forth between the cuticle and the epidermal cells, small, scattered or often densely confluent on the leaves and leaf stems. Primary uredosori usually densely confluent on leaves and stems and young branches, causing them to become swollen and collected into globose bundles or "witches' brooms," 0.5–2 cm in diameter; later uredosori more or less scattered over the leaves, often densely confluent over the entire surface of the young pods, tawny, sori small, usually less than 1 mm in diameter and on both sides of the leaves; uredospores fulvous, walls thick, primary spores globose, often angular, later ones oval to globose, densely spinulose, 13–17 by 17–23 μ; germ pores many, scattered; paraphyses very abundant, clavate, 40–50 by 5–12 μ, heads fulvous, pedicel hyaline. Teleutosori small, less than 1 mm, black-brown, on both sides of the leaves and on the leaf stems; teleutospore heads chestnut-brown, papillate, orbicular, 70–85 by 30–35 μ thick; spores 5–6 in cross section, each with several (3–4) short hyaline papillae, 17–20 by 33–38 μ, tips intensely dark brown for 7 μ; cysts ovate-oblong, hyaline, beneath entire head, pendent; pedicel hyaline compound, short, deciduous.

On *Mimosa fragrans:* Austin, Texas, June 7, 1901, no. 142.

This species is very closely related to *Ravenelia expansa*, but differs from it in the cysts being beneath the entire head, while in *R. expansa* they are only under the marginal spores; the paraphyses are narrower and more abundant, and the uredospores are darker and more elliptical than those of *R. expansa*. This rust was collected during June and July; very few teleutosori were present; by the close of July all the infected leaves had fallen from the host.

RAVENELIA SPINULOSA Diet. and Holw., BOT. GAZ. **31**: 336. 1901.—*Fig. 15.*

Sori breaking forth between the cuticle and the epidermal

cells, on both sides of the leaves. Uredosori ochre color, often confluent in effused patches, 0.5–1 mm in diameter; uredospores oval to spheroid, densely echinulate, light brown, 17–20 by 20–30 μ, usual size 18 by 25 μ; germ pores many, scattered; paraphyses rare, capitate-clavate, much attenuated toward base, hyaline, 10–15 by 30–50 μ. Teleutosori black-brown, small, scattered; teleutospore heads chestnut-brown, papillate, irregularly orbicular, 50–120 by 30–40 μ thick; 5–7 spores in cross section, each with a single hyaline (2–7 μ) papilla; cysts hyaline, globose, 13–15 μ in diameter, pendent, beneath the entire head; pedicel short, hyaline, deciduous, compound.

On *Cassia Lindheimeriana:* San Marcos, Texas, Nov. 19, 1901; Marble Falls, Texas, March 30, 1901; Austin, Texas, Aug. 24, 1901, no. 1026; Austin, Texas, Oct. 5, 1901, leg. *A. M. Ferguson.*

On *Cassia multiflora*: Oaxaca, Mexico, Oct. 18, 1899, no. 3675 (type) *Holway.*

RAVENELIA ARIZONICA Ell. and Ev., Bull. Torr. Bot. Club **22**: 363–364. 1895; Saccardo Syll. Fung. **14**: 367. 1899.—*Fig. 16.*

Sori subepidermal, on both sides of the leaves but mainly on the under side. Uredosori chestnut-brown, firm, scattered, 0.5–1 mm broad, oval to orbicular; uredospores obovate to oblong-ovate, spinulose, light brown, apex often darker, 17–20 by 28–36 μ; germ pores 4, equatorial; paraphyses of two kinds, normal form capitate, heads dark brown, walls thick: pedicel usually hyaline, somewhat attenuated toward base; heads 20–23 μ in diameter, pedicels 30–60 by 7 μ; the other form cystoid, walls thin, clavate-fusiform with apex nipple-shaped, slightly fulvous, rare. Teleutosori dark brown, orbicular, 80–100 μ in diameter, spinous; 6–8 spores in cross section, tips intensely brown for 6 μ, 10–15 by 25–33 μ, each crowned with a curved hyaline spine 4–6 μ long; cysts hyaline, spheroid in a dense cluster beneath the head, pendent, swelling and bursting in water; pedicel compound, hyaline, short, deciduous.

On *Prosopis juliflora:* Abilene, Texas, 1900, no. 1481, Ell. and Ev. Fung. Col. continued (issued as *R. decidua* (Pk) Holw.).

On *Prosopis velutina:* Tucson, Ariz., no. 37, *J. W. Toumey* (type); also Oct. 21, 1894, *J. W. Toumey;* Nov. 1900, no. 252 and no. 252a, West Am. Fung.

The no. 252a of West American Fungi is very interesting, as the uredospores are borne on large woody galls, which are densely covered with the confluent sori; the spores on these vary greatly in shape and size. The galls, Mr. Griffiths writes me, are perennial, bearing successive crops of uredospores year after year. The teleutospores are on the leaves of the same trees that have the uredospore-bearing galls, but no teleutospores were found on the galls. This gall-bearing stage is very similar to the aecidial stage of *Neoravenelia Holwayi*, only in this case the spores are not in chains, but are true uredospores and are intermixed with the characteristic paraphyses. The galls also are larger and woody, while those of *Neoravenelia Holwayi* are brittle, and shrink very much in drying, and are annual.

This species was originally reported as on *Prosopis juliflora;* but this, Dr. David Griffiths writes me, was an error, as the host is *Prosopis velutina* Wooton.

RAVENELIA APPENDICULATA Lagerh. and Diet., Hedwigia **33**: 47, 65. 1894; Saccardo, Syll. Fung. **11**: 210. 1895.—*Fig. 8.*

Sori subepidermal, mainly on the under side of the leaves, scattered. Uredosori cinnamon color, small; uredospores fulvous to hyaline, ovate, verrucose, 20–23 by 26–30 μ, germ pores four, equatorial; paraphyses clavate, stout; heads evenly brown, 17–24 by 29–30 μ; pedicel hyaline, short, 26–33 by 7 μ. Teleutosori small, black; teleutospore heads irregularly orbicular, chestnut-brown, 65–90 μ in diameter, appendaged; 4–5 spores in cross section, 18–20 by 25–30 μ, each with a long (8–12 by 5 μ) fulvous appendage which is branched at the apex; cysts hyaline, peripheral, pendent; pedicel compound, hyaline, short, deciduous.

On *Phyllanthus galeottinus:* Cuernavaca, Mexico, Sept. 15, 1899; also Guadalajara, Mexico, Oct. 12, 1896, *Holway*.

On *Phyllanthus* sp.: Ecuador, prov. Chimborazo, Puenti de Chimbo, Aug., 1891, *G. v. Lagerheim*.

RAVENELIA MEXICANA Transchel, Dietel in Hedwigia **33**: 370. 1894.—*Fig. 25.*

Sori breaking forth between the cuticle and the epidermal cells, scattered, on both sides of the leaves, very small, fulvous, surrounded by the ruptured cuticle. Uredospores intermixed with teleutospores (rare in specimens examined), ovate to spheroid, fulvous, echinulate; germ pores 4 (?), equatorial, walls thin, 18–20 by 23–25 μ; paraphyses in separate sori,

clavate-capitate; heads light brown; pedicel hyaline, 18–20 by 40–55 μ. Teleutospore heads light brown, spinous, irregularly orbicular, 60–80 by 35 μ thick; spores 4–5 in cross section, each crowned with 2–4 blunt, curved hyaline spines, which range from mere warts to spines 8 μ long by 4 μ thick at base; cysts when dry, flat, and closely appressed to the under side of the heads, but in water swelling into an oblong shape and finally bursting, peripheral; pedicel weak, short, deciduous.

On *Calliandra grandiflora* Benth.: Mexico, State of Jalisco, mountains near Lake Chapale, Sept. 12, 1889, leg. *Pringle*.

The spines in this species are very variable in size and shape. Very few uredospores were present in the specimen examined, which was a part of the type collection kindly sent me by Dr. Dietel. For this reason, the number and position of the germ pores could not be determined with certainty.

Ravenelia leucaenae, n. sp.—*Fig. 23*.

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper side of the leaves, scattered very sparingly on the leaf stems. Uredosori cinnamon-brown, very small, from punctate to 0.4–0.6 mm, elliptical, surrounded by the ruptured cuticle; uredospores pale brown, base often semi-hyaline, with a darker but unthickened apex, oblong-linear to oblong-oval and sometimes oblong-ovate, usual shape oblong-linear, sparsely spinulose, 15–18 by 35–50 μ; germ pores 4, in the equator or between it and the base of the spore; paraphyses common, semi-hyaline, fulvous at apex, subclavate to sub-capitate, walls very thin, often collapsed, 18 by 40–50 μ. Teleutosori chestnut-brown, small, 0.4–0.6 mm in diameter, surrounded by the ruptured cuticle; teleutospore heads chestnut-brown, orbicular, 65–90 by 35–40 μ thick, papillate; 5–6 spores in cross-section, each spore crowned with several hyaline papillae 4–7 by 2–3 μ.; cysts oblong-ovate, flattened at base, peripheral, hyaline, swelling and finally bursting in water; pedicel short, hyaline, deciduous, apparently of separate hyphae.

On *Leucaena diversifolia:* Etla, Oaxaca, Mexico, Oct. 25, 1899, no. 3826, *Holway* (type).

On *Leucaena* sp.: Iguala, Mexico, Oct. 3, 1900, *Holway*.

This species is related to *R. goyazensis*, but differs from it in its shorter and hyaline papillae, in the shape of its cysts, and in the very small size of

its sori. It differs from *R. Pazschkeana* Diet. in the unthickened apices of its uredospores and in the longer papillae, and in being subcuticular while *R. Pazschkeana* is sub-epidermal.

PLEORAVENELIA, n. gen.

Spermogonia formed between the cuticle and the epidermal cells, hemispherical. Aecidia with a well developed pseudoperidium. Uredospores borne singly on short stalks; germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads formed of several or many cells; inner teleutospores two-celled by transverse or more or less oblique septa; outer spores one-celled; under side of teleutospore heads with several or many hyaline cells or cysts; pedicel of the head of several hyphae, which are either separate or united into a compound stipe.[1]

KEY TO SPECIES.

1. Teleutospore heads smooth - - - - - - - - 2
   Teleutospore heads rough, warty, etc. - - - - - - 3
2. Uredospore germ pores many (12–15), scattered; paraphyses many, clavate - - - - - - - - - - - *P. laevis*
   Uredospore germ pores 6–13, equatorial; paraphyses none - - 4
3. Uredospore germ pores many, scattered; paraphyses many; teleutospore heads papillate - - - - - - *P. indigoferae*
   Uredospore germ pores many, scattered; teleutospore heads warty and appendaged at base - - - - - - *P. brongniartiae*
   Uredospore germ pores 4–6, equatorial; teleutospore heads minutely verrucose - - - - - - - - - - *P. talpa*
4. Germ pores 6. Uredospores fulvous, 25 by 34 μ - *P. epiphylla*
   Germ pores 8–12; uredospores brown, 20 by 25 μ - - *P. similis*

Pleoravenelia laevis (Diet. and Holw.)—*Fig. 17.*

Ravenelia laevis Diet. and Holw., BOT. GAZ. **27**:35. 1897; Saccardo, Syll. Fung. **14**:366. 1899.

Sori subepidermal, on yellow spots on both sides of the leaves. Uredosori cinnamon color, few, small, surrounded by the ruptured epidermis; uredospores brown, oval to globose, spinulose, 21–26 by 22 μ; germ pores many (15 or more), scat-

[1] The other Ravenelias with the inner spores two-celled, which are not included in this paper, will also come under the new genus *Pleoravenelia*, and should be written **Pleoravenelia Hieronymi** (Speg), **P. MacOwaniana** (Pazschke), **P. glabra** (Kalchbr. and Cke.), and **P. tephrosiae** (Kalchbr.).

tered; paraphyses large, clavate, many, uniformly brown; heads 26–35 by 40 μ; stipe 40–65 by 10–12 μ, hyaline. Teleutosori black-brown, from punctate to 1 mm in diameter, abundant; teleutospore heads irregularly orbicular, dark brown, opaque, smooth, 85–120 μ in diameter; 5–6 spores in cross section; cysts cushion-shaped, connate with the pedicel, peripheral; pedicel compound, short, hyaline.

On *Indigofera densifolia:* Oaxaca, Mexico, Oct. 18, 1899, no. 3661, Holway.

On *Indigofera* sp.: Esclava, near City of Mexico, Oct. 3, 1896, Holway.

Differs from *P. epiphylla* and *P. similis* in having paraphyses, and in the numerous germ pores (15 or more).

Pleoravenelia similis, n. sp.—*Fig. 21.*

Sori subepidermal, on effused yellow spots, from punctate to 0.5 mm in diameter, on both sides of the leaves but especially abundant on the upper surface and more or less confluent over large areas. Uredosori few, ochraceous, small; uredospores brown, walls thick and dark brown, spinulose, oval to subglobose and often ovate, 20–28 by 17–23 μ; germ pores 8–12, irregularly scattered in or near the equatorial zone; paraphyses none. Teleutosori black-brown; teleutospore heads smooth, irregularly orbicular to oval, chestnut-brown, 68–135 μ, usual size 100 μ; 6–8 spores in cross section; cysts hyaline, peripheral and decurrent into the pedicel; pedicel hyaline, compound, short.

On *Brongniartia:* Guadalajara, Mexico, Sept. 14, 1899, no. 3145, *Holway* (type); also Oct. 1896, *Holway.*

The uredospores of this species blacken very much under continued boiling in lactic acid and glycerine solution, and shrink somewhat, while the uredospores of *P. epiphylla* do not blacken or shrink. It also differs from *P. epiphylla* in the number of germ pores, and in the brown uredospores.

Pleoravenelia epiphylla (Schw.).—*Fig. 18*

Sphaeria epiphylla Schw., Syn. Fung. Carol no. 130 p. 40. 1822; Saccardo, Syll. Fung. 2: 399. 1883; Farlow, Host Index 30. 1888; Ellis and Everhart, N. A. Pyren. 745. 1892.

Ravenelia glanduliformis Berk. and Curt., Cooke in Jour. Roy. Micr. Soc. 3:385. 1880; Grevillea 3:56. 1874; Parker, Proc. Amer. Acad. 21:205–

217. 1886; Atkinson, Some fungi from Alabama, Bull. Cornell Univ. Science 3: 20. 1897.

Ravenelia epiphylla Dietel, Hedwigia 3: 27–29, 59. 1894.

Sori subepidermal, on both sides of the leaves and on the leaf stems and branches, scattered, crowded or confluent. Uredosori small, ochraceous, surrounded by the ruptured epidermis, scattered, usually confined to the leaves; uredospores fulvous to semi-hyaline, walls thin, broadly oval to broadly ovate, verrucose, 30–40 by 23–26 μ, usual size 34 by 25 μ; germ pores 6, in the equator; paraphyses none. Teleutosori on both stems and leaves, scattered or confluent, black-brown; teleutospore heads chestnut-brown, very variable as to size and shape, smooth, 80–115 by 33–45 μ thick; 4–7 spores in cross section; cysts hyaline, decurrent into the pedicel; pedicel short, hyaline.

On *Tephrosia virginiana:* South Carolina, 1876, *Ravenel*, no. 1251, Thümen Myc. Univ. Fungi Car.; Rav. Fung. Car. no. 72; White Sulphur Springs, West Va., no. 705, *M. B. Waite;* Oregon, Ill., Sept. 3, 1886, no. 84, *M. B. Waite;* Munith, Mich., 1893, *G. A. Hicks*, no. 1787, Plants of Mich.

On *Tephrosia* sp.: South Carolina, *Aiken*, no. 55, Rav. Fung. Am. Exsic.

On *Tephrosia hispidula:* Auburn, Alabama, Sept. 9, 1893, *Duggar;* Auburn, Ala., Sept.–Oct. 1891, *Duggar* and *Atkinson;* Oct. 11, 1891, no. 2208, *Atkinson;* Center, N. Y., *Peck*, no. 363, Ell. N. A. Fung.

On *Tephrosia spicata:* Lake City, Florida, Oct. 16, 1899, no. 17, Fungi of Fla., *H. H. Hume;* Auburn, Alabama, no. 2146, *Atkinson.*

In all specimens of this species examined the uredospores were typical of the species and distinctly different from the uredospores of *P. similis* on Brongniartia.

Pleoravenelia indigoferae (Transz.).—*Fig. 19.*

Ravenelia indigoferae Transz., Dietel in Hedwigia 33: 369, 1894; Saccardo, Syll. Fung. 11: 211. 1895.

Sori subepidermal, on both sides of the leaves and on the leaf stems and branches. Uredosori sparse in material examined, pale yellow, small; uredospores oval to globose, 20–23 by 23–27 μ, epispore with sparse short prickles, light yellow; germ pores many, scattered; paraphyses many, clavate to subcapitate, brownish, walls of heads dark brown, contents faintly brown, 20–25 μ; stipe hyaline, 50–80 by 7 μ. Teleutosori black, small, scattered on the leaves; on the stems and branches

confluent and causing large swollen places of several centimeters in extent; teleutospore heads irregularly orbicular, chestnut-brown, 80–125 μ broad, beset with pale brown papillae (3 by 4–6 μ); 4–6 spores in cross section, each spore crowned with several (4–8) papillae.

On *Indigofera cuernavacana* Rose: Cuernavaca, Mexico, Sept. 28, 1898, no. 3120, *Holway*.

On *Indigofera Palmeri* Wats.: Oaxaca, Mexico, Oct. 19, 1899, no. 3682, *Holway*.

Pleoravenelia brongniartiae (Diet. and Holw.)—*Fig. 20.*

Ravenelia brongniartiae Diet. and Holw., BOT. GAZ. 35: 1897; Saccardo, Syll. Fung. 14: 368. 1899,

Sori breaking forth from beneath the epidermis. Uredosori single or clustered, on both sides of the leaves, cinnamon-brown, spots large, yellow, about 5^{mm} in diameter; uredospores ovate to globose, 23–30 by 18–25 μ, spinulose; germ pores many, scattered; paraphyses none. Teleutosori not on spots, black; teleutospore heads orbicular, 85–115 μ in diameter, chestnut-brown, entire surface densely covered with large warts, while each marginal spore has one large dark brown blunt process; 5–6 spores in cross section, spores 16–21 μ long; cysts united into a coniform body which is decurrent into the pedicel; pedicel compound, short, hyaline.

On *Brongniartia* sp.: Cuernavaca, Mexico, Sept. 29, 1899. no. 3591, *Holway;* Sept. 28, 1898, no. 3022 and no. 3170, Sept. 23, 1896.

On *Brongniartia sericea:* Oct. 18, 1899, no. 3663, *Holway*.

On *Brongniartia intermedia:* Tizapan, near City of Mexico, Sept. 27, 1899, no. 3504½, *Holway*.

All from Herb. E. W. D. Holway.

Pleoravenelia talpa, n. sp.—*Fig 22.*

Sori subepidermal, thickly distributed over both sides of the leaves. Uredosori few, ochraceous, surrounded by the ruptured epidermis, small; uredospores brown, walls thick, verrucose, ovate to subglobose, usually inequilateral, 25–32 by 18–22 μ, usual size 30 by 20 μ; germ pores equatorial, 4–6, not easily visible even after boiling in lactic acid; paraphyses none. Telutosori small, black-brown, many, surrounded by the rup-

tured epidermis; teleutospore heads dark brown, irregularly orbicular to oval, minutely but distinctly verrucose, 65–115 by 35–40 μ thick, usual size 85 μ; 4–8 spores in cross section, each spore crowned with several small scattered semi-hyaline warts, which are not arranged along the margins of the spores; cysts hyaline, peripheral, decurrent into the pedicel, swelling and bursting in water; pedicel compound, short, hyaline.

On *Tephrosia talpa* Wats.: Oaxaca, Mexico, Oct. 19, 1899, no. 3679, *Holway*.

This differs from *R. epiphylla* in its warty head, smaller and browner uredospores; and from *R. tephrosiae* in the very small warts of its teleutospores and in its larger uredospores, as a careful comparison with type specimens showed.

NEORAVENELIA, n. gen.

Spermogonia breaking forth between the cuticle and the epidermal cells, hemispherical. Aecidia without a pseudoperidium, borne caeoma-wise. Uredospores borne singly on short stalks; germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads, formed of several or many spores; all the spores of the entire head one-celled; under surface of teleutospore heads with several or many hyaline cells or cysts; pedicel of the head of several hyphae, which are either separate or united into a compound stipe.

Neoravenelia Holwayi (Diet.).—*Fig. 24.*

Ravenelia Holwayi Diet., Hedwigia 33: 52–53, 61. 1894; Saccardo, Syll. Fung. 11: 216. 1895.

Aecidial stage forming galls and cap-shaped excrescences on the leaves and leaf stems; galls oblong to globose, more or less curled and distorted, very variable in size, 1–4 cm long by 2–6 mm thick; "caps" on the leaflets 1–2 mm tall by 3–5 mm broad, with the concavity on the lower side of the leaflet; spermogonia on both sides of the "cap," subcuticular, preceding and with the aecidiospores, dark brown, 46–60 μ in diameter.

I. Aecidiosori deep seated, mummy-brown when fresh, ochraceous when desiccated, oblong to oval, 1–3 mm long by 1 mm broad, finally becoming more or less confluent over the entire surface of the galls, opening by a median longitudinal slit; sori

usually concentrically disposed on the convex and upper surface of the "caps;" pseudoperidium none; aecidiospores in chains, caeoma-wise, spores linear-oblong to subovate, very irregular in shape and size and often angular or prolonged into a point at one or both ends; walls thick, densely granular, light brown, 13–20 by 30–40 μ; germ pores 4, equatorial, faint.

Uredo- and teleutosori subepidermal, on both sides of the leaves and sparingly on the leaf stems.

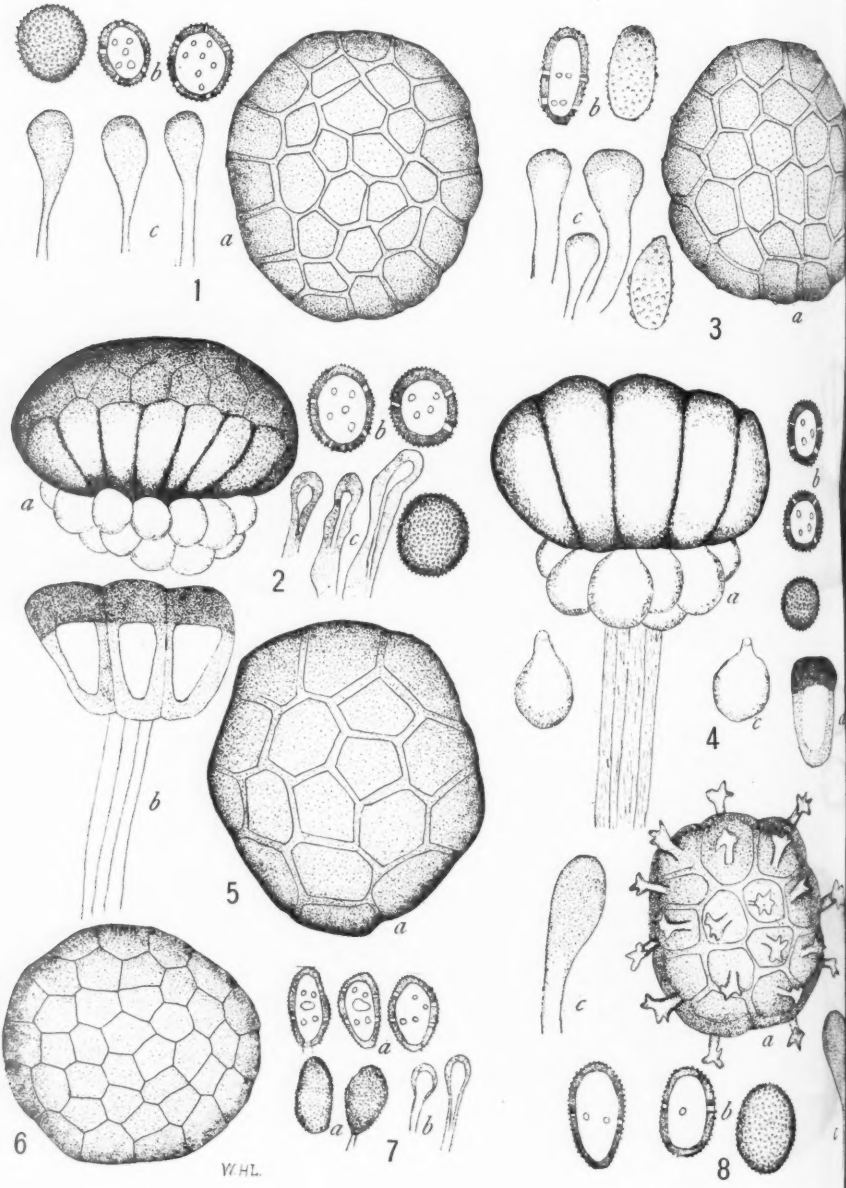
II. Uredosori orbicular to elliptical, averaging 0.3–0.5 mm, sometimes 0.6–0.7 mm in diameter, cinnamon-brown, or chestnut-brown when many paraphyses are present; uredospores oval to obovate to fusiform, 17–24 by 32–45 μ, fulvous, darker and thickened somewhat at the apex, spinulose; germ pores four, equatorial; paraphyses many, capitate; heads intensely dark brown, 15–20 by 20–25 μ; pedicels stout, hyaline to fulvous, 5 by 20–35 μ.

III. Teleutosori black, scattered, large, 0.75–1–2 mm in diameter; teleutospore heads intensely dark brown, opaque, apex depressed, smooth, 100–150 μ in diameter; 6–10 spores in cross section, each spore 15–20 by 40–45 μ, apex intensely brown for 12–14 μ, remainder of spore semi-hyaline; cysts hyaline, many, beneath the entire head, pendent, ovate to spheroid, swelling and bursting in water; pedicel hyaline, compound, or of separate hyphae, short, deciduous.

On *Prosopis juliflora:* Austin, Texas, May 8, 1901, no. 909 (type of aecidial stage); Aug. 26, 1901, no. 1031 (type for II and III); July 2, 1900, no. 25; Oct. 25, 1900, no. 10; Denton, Texas, June 12, 1902 (I), and Oct. 20, 1902 (III); College Station, Texas, July–Aug. (II), 1888, leg. *Pammel;* Texarkana, Texas, Nov. 5, 1899 (III), *Holway*; San Bernardino, Cal.; leg. *S. B. Parish*, no. 2541 (type of *R. Holwayi* Diet.).

The galls appear soon after the leaves are expanded. In about two weeks the aecidiosori began to open; the galls persist on the trees for several weeks and then usually fall off. They are followed in about two weeks by the uredosori which do not form galls. The uredospore stage continues till October, when the teleutospores begin to appear and these continue till frost kills the leaves of the host.

The rust usually infests trees that are in a low, damp situation, as on the margin of a stream or in a ravine. The "caps" usually appear before the galls and seem to be confined to the leaflets, while the galls are on the leaf stems and young branches.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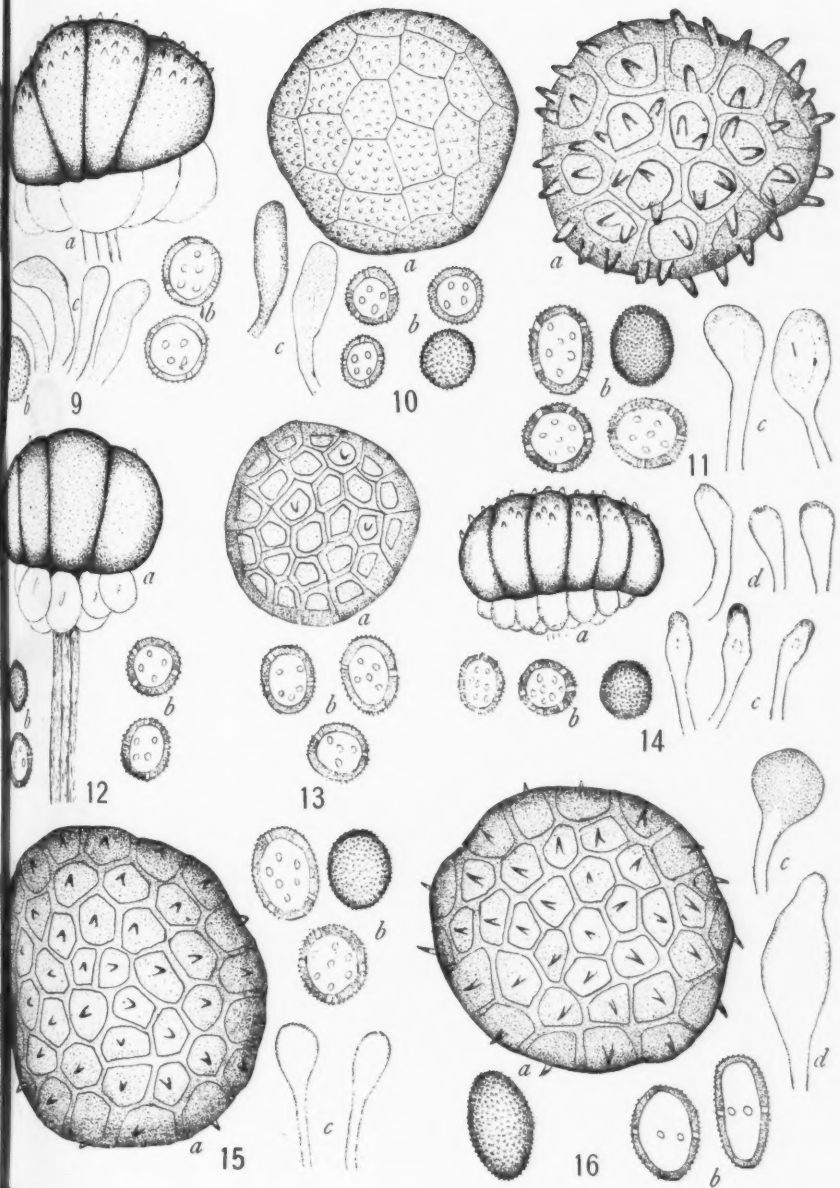
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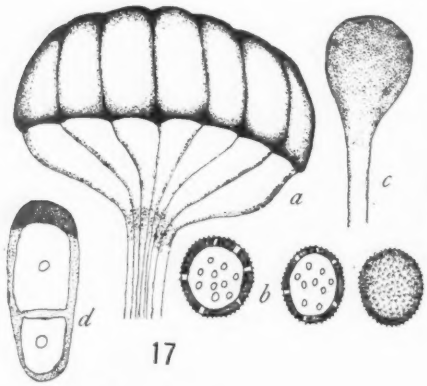

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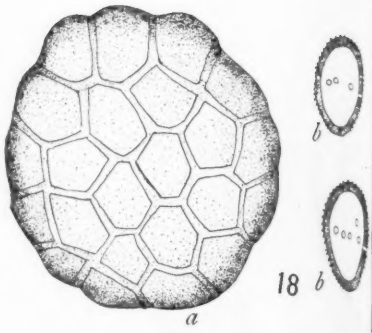

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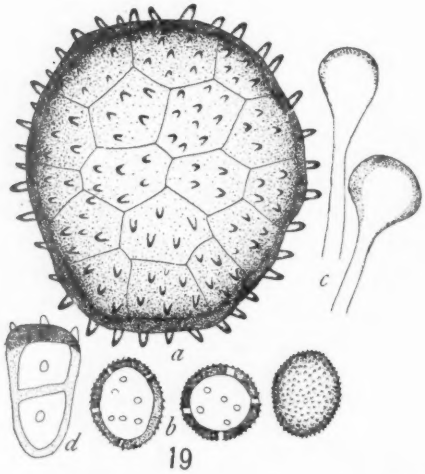

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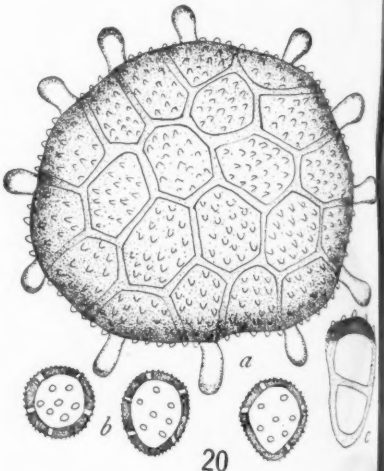

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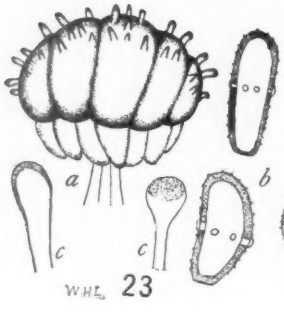

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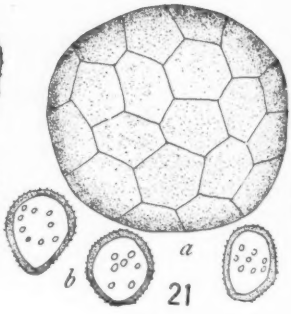

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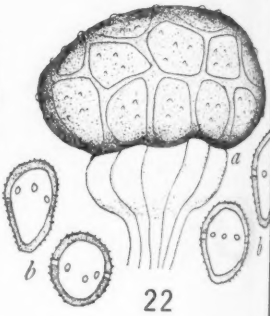

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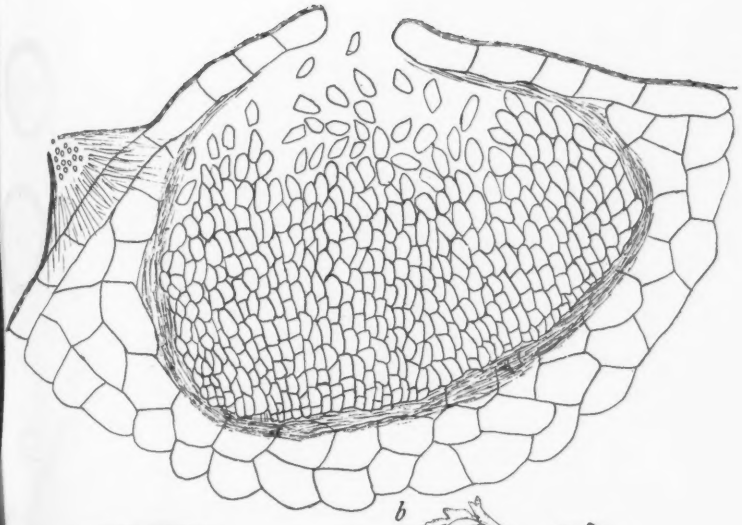

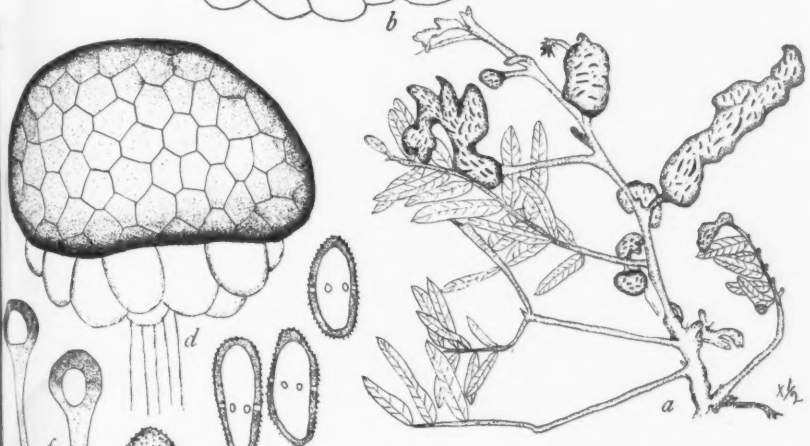

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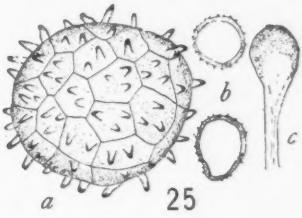

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All three stages have been repeatedly found by the writer on the same trees, the aecidial stage first and the other stages appearing in due time. Occasionally an old dead gall will continue on the trees till the next spring. The descriptions were all drawn from material collected at Austin, Texas.

There is some doubt in the writer's mind about this species being identical with the old *Ravenelia Holwayi*, as there are several minor differences, but none apparently of sufficient value to separate it from *R. Holwayi* Diet. The aecidial stage being of the caeoma type throws it into a new genus.

DENTON, TEXAS.

EXPLANATION OF PLATES II AND III.

All figures except *24a* and *24b* are magnified, after reduction, 400 times; *24a*, as indicated on plate and *24b* are magnified 80 times.

FIG. 1. *Ravenelia texana:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 2. *Ravenelia Longiana:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 3. *Ravenelia versatilis:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 4. *Ravenelia indica:* *a*, teleutospore head; *b*, uredospores; *c*, cysts; *d*, simple teleutospore.

FIG. 5. *Ravenelia opaca:* *a*, teleutospore head; *b*, three teleutospores and pedicel.

FIG. 6. *Ravenelia Farlowiana:* teleutospore head.

FIG. 7. *Ravenelia siliquae:* *a*, uredospores; *b*, paraphyses.

FIG. 8. *Ravenelia appendiculata:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 9. *Ravenelia verrucosa:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 10. *Ravenelia expansa:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 11. *Ravenelia mimosae-sensitivae:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 12. *Ravenelia cassiaecola:* *a*, teleutospore head; *b*, uredospores.

FIG. 13. *Ravenelia mesillana:* *a*, teleutospore head; *b*, uredospores.

FIG. 14. *Ravenelia fragrans:* *a*, teleutospore head; *b*, uredospores; *c*, common or typical paraphyses; *d*, uncommon forms of paraphyses.

FIG. 15. *Ravenelia spinulosa:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 16. *Ravenelia arizonica:* *a*, teleutospore head; *b*, uredospores; *c*, typical form of paraphyses; *d*, cystoid paraphysis.

FIG. 17. *Pleoravenelia laevis:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses; *d*, teleutospore.

FIG. 18. *Pleoravenelia epiphylla:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses; *d*, teleutospore.

FIG. 20. *Pleoravenelia brogniartiae:* *a*, teleutospore head; *b*, uredospores; *c*, teleutospore.

FIG. 21. *Pleoravenelia similis:* *a*, teleutospore head; *b*, uredospores.

FIG. 22. *Pleoravenelia talpa:* *a*, teleutospore head; *b*, uredospores.

FIG. 23. *Ravenelia leucaenae:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 24. *Neoravenelia Holwayi:* *a*, galls with aecidiosori on them; *b*, an aecidiosorus and one spermogonium; *c*, aecidiospores; *d*, teleutospore head; *e*, uredospores; *f*, paraphyses.

FIG. 25. *Ravenelia mexicana:* *a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

BRIEFER ARTICLES.

CHALAZOGAMY IN CARYA OLIVAEFORMIS.

NAWASCHIN[1] announced in 1895 that the pollen tube in *Juglans regia* does not enter the micropyle, but passes down the ovary wall and enters the ovule through the chalaza. It was not surprising, therefore, when in examining some longitudinal sections of pecan fruits I found the chalazal region of the ovules penetrated by pollen tubes. The material was gathered in the spring of 1902, a few days after the withering of the anthers. Though insufficient in amount for embryological work, for which the specimens were primarily collected, they show undoubted evidence of chalazogamy.

The general morphological character of the ovary wall and ovule resembles that of Juglans as described by Nawaschin. The placenta nearly fills the lower part of the ovary cavity on two opposite sides, and actually fuses with the ovary wall on the two sides lying in a plane at right angles to the first two. These two regions of fusion, lying on opposite sides of the placenta, correspond to the "flügelartige Wucherungen" of Juglans, and form, as do the "Wucherungen," the tissue through which the pollen tube travels to reach the base of the ovule. The single integument tightly encloses the orthotropous ovule. A micropylar canal is present, but is bent near its upper end, thus bringing its aperture into a lateral rather than apical position. No pollen tubes were found entering the canal.

The course of the fibrovascular bundles from the ovary wall to the ovule is not through the length of the placenta, but transversely through its upper part to a region immediately under the funiculus, at which point they turn abruptly upwards and pass through the chalaza into the integument. Two bundles enter in this manner from either side through the region of fusion, and then curve so as to approach each other under the funiculus in a plane approximately at right angles to that of the two regions of fusion. Such an arrangement leaves the coast clear for the direct passage of the pollen tube from the ovary wall to the funiculus.

[1] NAWASCHIN, S., Ein neues Beispiel der Chalazogamie. Bot. Centralbl. **63**: 353–357. 1895.

The so-called conducting tissue of the style consists of cells elongated in the direction of the long axis of the ovary, and differs in no material respect from that ordinarily seen. The pollen tube passes down the axial tissue of the style till near the cavity of the ovary, where it turns and passes down the ovary wall close to the margin of the cavity. The tissue through which it passes after leaving the style has nothing by which it could be designated "conducting tissue," but consists of nearly isodiametric cells. When a point is reached a little below the funiculus, the pollen tube curves, passes through a region of deeply-stained cells (as though mucilaginous), and when under the ovule turns upward towards the embryo sac.

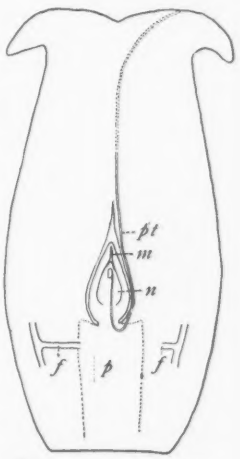

Diagram illustrating chalazogamy in the pecan: *p*, placenta, cut in the plane of fusion with the ovary wall; the approximate lines of fusion are represented by dotted lines; *f*, fibrovascular bundles running to the ovule; *n*, nucellus; *m*, micropylar canal; *pt*, pollen tube.

While the course of the tube is not difficult to see in the ovary wall, it is particularly conspicuous as it passes through the parenchymatous cells of the chalaza and nucellus. The account of the course taken by the pollen tube, as described above, is essentially that given by Nawaschin for Juglans. The branching of the tube recorded by Nawaschin appears to have its counterpart in the pecan. Although I have not settled this point by a number of observations, yet I did see a distinct branching in one case, and nearly every ovule examined showed the presence of more than one tube in the nucellus. If branching occurs, it takes place after the pollen tube has entered the subfunicular tissue.

Nothing definite has been made out as to the process of fertilization, or the nature of the embryo sac, but it is hoped that additional material will reveal something of interest along these lines.—FREDERICK H. BILLINGS, *Louisiana State University*.

SELECTED NOTES.

LEAF VARIATION IN *Liriodendron Tulipifera*.—A recent article by E. M. Berry on the phylogeny of Liriodendron (BOT. GAZ. 34: 44–63. 1902) attracted my attention to the subject of leaf variation in this

genus. The subject was mentioned to the students, and in a few days Mr. Ivey Lewis found a tulip tree with very variable leaves, from which we collected a number of forms. The tree was a fairly vigorous one, about eighteen feet high, growing on the edge of an open field. *Fig. 1* is from a photograph of six selected leaves from this tree. The type of variation represented by the two pointed leaves shown is of

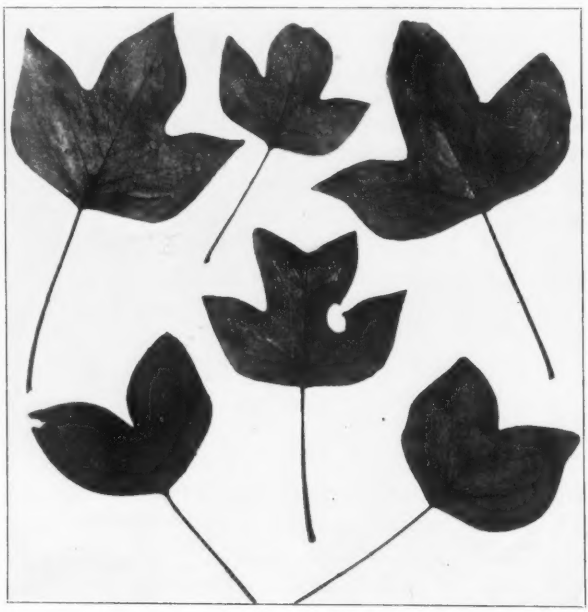

FIG. 1.—Photograph of six leaves from a single tree of *Liriodendron Tulipifera*. The tip of one leaf that was broken off after drying has been inserted in the photograph.

very rare occurrence in the living species, and apparently so far has been described by Berry only (Torreya 2:33. 1902). As the leaves of Liriodendron are usually considered remarkably constant to type, it was thought that a photograph of such widely different forms produced on the same tree might be of interest.

ON THE OCCURRENCE OF TWO EGG CELLS IN THE ARCHEGONIUM OF MNIUM.—While sectioning the female "flowers" of an undetermined species of Mnium, collected near Baltimore in the spring of

1900, an archegonium was found which contained two well-developed egg cells of perfectly normal appearance. The supernumerary one lay directly over the other, being inserted as a link in the axial row of cells present. *Fig. 2* represents their arrangement. Each egg has cut off its ventral canal cell above and is apparently ready for fertilization. One neck canal cell (*nc*) is shown. It seems probable that the upper egg cell has been derived from the lower neck canal cell by an abnormal modification of the latter. This is the only case, as far as I know, where two eggs have been observed in the archegonium of any of the archegoniates.

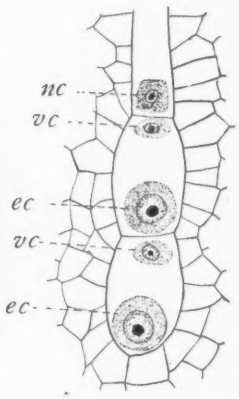

FIG. 2.—Part of venter of archegonium of Mnium, with two eggs and two ventral canal cells: *ec*, egg cell; *nc*, neck canal cell; *vc*, ventral canal cell. × 1050.

THE NUCLEUS OF THE SPORE CAVITY IN PROTHALLIA OF MARSILIA.—The nucleus left with the food material in the cavity of the megaspore on the formation of the prothallium seems to have been much neglected. Campbell (*Mosses and Ferns*, p. 404) figures this nucleus apparently disorganizing in *Marsilia vestita*, and speaking of Azolla says (*ibid.*, p. 384) "the nucleus of the lower cell remains in the upper part, and is much like that of the prothallial cell." With these exceptions this nucleus seems to have received little attention. While studying the prothallium of *Marsilia Drummondii*, notes were made on

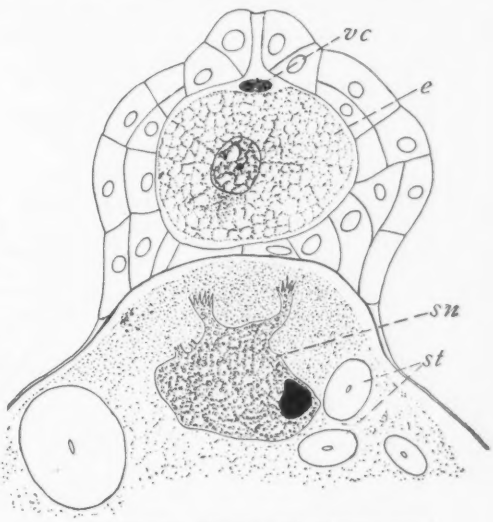

FIG. 3.—*Marsilia Drummondii*, showing upper part of megaspore with archegonium: *vc*, ventral canal cell; *e*, egg; *sn*, large nucleus in megaspore cavity; *st*, starch grains. × 670.

the intersporic nucleus which may be worth recording. The nucleus enlarges greatly as development proceeds, retains its position at the tip of the spore cavity, and at the time of fertilization is vastly larger than the nuclei of the remaining tissue, as shown in *fig. 3*. In this figure the peculiar shape of the nucleus attracts attention. Two long arms are projecting towards the prothallium, and other filaments extend upward from one side. The shape of the nucleus is not at all constant, but at this stage it is generally furnished with fine extensions radiating towards the prothallium. *Fig. 4* shows the nucleus of another spore at the same stage. As development proceeds, the nucleus frag-

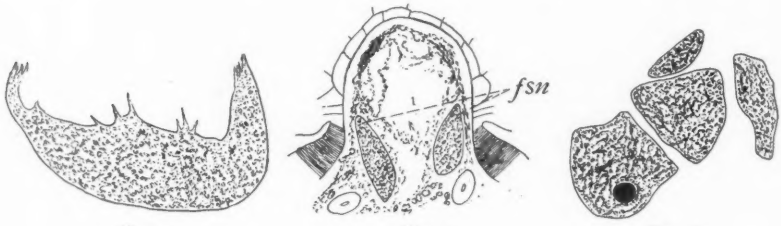

FIG. 4. FIG. 5. FIG. 6.

FIG. 4.—The same as *fig. 3*, showing nucleus of spore cavity. × 1050.

FIG. 5.—The same as *fig. 3*, showing papilla of spore cavity with two fragments of the nucleus (*fsn*); later stage than above. × 370.

FIG. 6.—The same as *fig. 3*, showing fragmentation carried still further. × 1050.

ments amitotically into a number of parts. *Fig. 5* represents two such fragments, one on each side, after the embryo has begun to develop. In *fig. 6* fragmentation has proceeded still further. The reticulum is throughout very dense and homogeneous and a nucleolus is present. It is hardly probable that the peculiar processes figured can be an artifact, as all other parts seem very well fixed. If these processes are normal, as seems probable, they recall the filaments extending from the nucleus into the food mass in the egg cell of Dytiscus (Wilson, *The Cell*, p. 115). In the case of Marsilia, however, the processes extend towards the tissue to be nourished, instead of towards the food material. The nucleus is here, doubtless, quite active in the elaboration or transference of food material, and it is not surprising that it should show special modification to this end. The final fragmentation reminds one of similar behavior of the nuclei in purely vegetable cells of Chara, Tradescantia, and many other plants.—W. C. COKER, *University of North Carolina, Chapel Hill.*

CURRENT LITERATURE.

BOOK REVIEWS.

Dune work in Germany.

IN THIS BOOK Gerhardt[1] presents a very comprehensive account of the historical development, as well as the present status, of dune control in the classic dune areas along the shores of the Baltic and North seas. He has been ably assisted in the geological, floristic, and sylvicultural aspects of the work by Jentzsch, Abromeit, and Bock, respectively. The sources of the sand, the factors at work, and the laws governing the movement and contour of the dunes are considered in some detail, as are also the ecological adaptations of the various species of dune plants. Historical records indicate that as early as 1738 the problem of controlling the shifting sand had been solved for certain areas; but the development of modern methods and organized work dates from about the beginning of the last century, when Biörn demonstrated that a certain combination of hedges, grass-plats, etc., is effective in checking the advance of a wandering dune. Krause and Hagen furthered the work of Biörn, both in the extension of the areas protected and in the improvement of methods. Near the town of Narmeln, situated on the Frischen Nehrung, occurs an example of their work. Two rapidly advancing dunes had already encroached upon the town limits when Krause began his work, which was prosecuted with such success that the threatening dunes were under complete control before serious damage was done, and although over half a century has passed, the town has never since been seriously threatened with a further advance of the dunes.

Excellent illustrations and diagrams aid in the clear exposition of the various devices with which the newly transplanted vegetation is protected, and the shifting sand captured and held. Directions for culture and detailed descriptions of the various grasses, shrubs, and trees recommended are given, together with a statement of the steps necessary to the final forestation of the wandering dune. The existing farms, with their gardens and orchards, where a hundred years ago were only sand wastes, and the wooded elevations that mark the site of once wandering dunes bear witness to the effectiveness of the methods used in these areas. And there appears no reason why these methods may not be successfully applied wherever the shifting sand endangers valuable property.—J. M. WESTGATE.

[1] GERHARDT, PAUL, Handbuch des deutschen Dünenbaues, pp. xxviii + 656 *figs.* 445. Berlin: Paul Parey. 1900.

French forests.

A VERY CAREFUL and thorough discussion of the forests of France has come from MM. Boppe and Joylet of the national school of forestry at Nancy.[2] The work begins with a discussion of the form and reproduction of a tree as influenced by its environment, followed by descriptions of the principal native species, in which the habitat, distribution, and forest value of each are given. Then follows a detailed treatment of the forest-stand, the influence of its trees upon the soil and upon each other. An aggregation of stands makes a forest. As concerns forests, the climate of France falls into two great divisions: (1) that of the plains, subdivided into three zones according to the distribution of the rainfall and the resultant forest growth; and (2) that of the mountains, the climate of each mountain system being treated separately.

The greater part of the book is devoted to a detailed discussion of the methods and principles of sylviculture as employed in France. Of special economic interest is the account of the reforestation of denuded mountain slopes and of the fixation of sand dunes.

In the treatment of the forests in their biological and sylvicultural relations this book covers the ground more thoroughly than any American treatise on a similar subject.—C. D. HOWE.

MINOR NOTICES.

ALICE R. NORTHROP[3] has published an account of the flora of two of the Bahama islands, with an enumeration of the plants collected by John I. Northrop and herself in 1890, a collection including 542 species. After some description of the general ecological features of the region, the list of plants is given. Several new species from the collection had previously been described by various authors, and the present publication contains additional new species, and also two new genera of palms (*Paurotis* and *Cyclospathe*), described by O. F. Cook. Following the list is a study of the relations of the Bahama flora, as illustrated by the collection of the author. Of the 453 native vascular plants found on New Providence and Andros, 176 are reported from other islands of the group, 335 from Cuba, 250 from southern Florida, 108 from southern United States, 286 from Jamaica, 190 from Virgin islands, 223 from Windward islands, 196 from Mexico and Central Mexico, and 199 from South America.—J. M. C.

NOTES FOR STUDENTS.

HUNGER[4] has studied the granules which occur in the thallus of Dictyota. He finds that the smaller ones near the plastids are of a monosac-

[2] BOPPE. L., and JOYLET, ANT., Les forêts, traité pratique de sylviculture, pp. xi + 488. 95 photogravures. Paris: J. B. Baillière & fils. 1901.

[3] NORTHROP, ALICE R., Flora of New Providence and Andros (Bahama islands). Mem. Torr. Bot. Club **12**: 1–98. *pls. 1–19.* 1902.

[4] HUNGER, F. W. T., Ueber das Assimilations-Product der Dictyotaceen. Jahrb. Wiss. Bot. **38**: 70–82. 1902.

charid nature. The larger granules in the interior of the cells are composed largely of polysaccharid and contain considerable tannin.—BURTON E. LIVINGSTON.

T. J. and M. F. L. FITZPATRICK[5] give a short account of the genetic development of the island vegetation of the Mississippi river near Sabula, Iowa. The characteristic species associated with the willow-cottonwood-elm society are listed and the significance of certain tendencies indicated.—J. M. WESTGATE.

HUŠEK[6] finds the grains in the root-cap of *Allium Cepa* to be the so-called "red starch;" beside amylodextrin they contain a little real starch and some dextrin. The red starch is formed only at ordinary temperatures. The amyloplasts are confined to the root-cap. If the tip is removed, they occur in the regenerated tip. They are formed there *de novo* from the cytoplasm in Allium.—E. B. COPELAND.

GUIGNARD[7] has just reported double fertilization among the Cruciferae. The forms studied were *Capsella Bursa-pastoris* and *Lepidium sativum*, which prove to be almost identical in their main features. The polar nuclei fuse late, just before the entrance of the tube, the fusion-nucleus lying very close to the oosphere. The male cells are small and ovoid, and after discharge from the tube pass so rapidly to the oosphere and the fusion-nucleus as not to be caught in the preparations during their passage. The fusion of the male cell with the endosperm nucleus is very much more rapid than the fusion of its mate with the egg. It seems to be more and more evident that the so-called double fertilization is a very general phenomenon among angiosperms.—J. M. C.

BREUNER[8] has made an ecological study of the oak leaves of the world, as to their general adaptations to their native climates. His work includes a study of cultivated or herbarium material from all lands where oaks grow, and some experiments upon living material to show the influence of illumination upon the size, form, and structure of the leaves. Except for the excessive individual variability of oak leaves, the genus is a most favorable one for such work. The results of experiments, and of local differences in environment correspond to the specific characters in the climates imitated; whence Breuner concludes "that the modifications in plants called forth by external causes become hereditable, and in the course of evolution may develop into specific characters."—E. B. COPELAND.

[5] FITZPATRICK, T. J. and M. F. L., A study of the island flora of the Mississippi river near Sabula, Iowa. Plant World **5**: 198–201. 1902.

[6] HUŠEK, G., Ueber Stärkekörner in den Wurzelhauben von *Allium Cepa*. Reprint, Sitzber. K. Böhm. Gesells. Wissens. 1902. 10 pp.

[7] GUIGNARD, L., La double fécondation chez les Crucifères. Jour. Botanique **16**: 361–368. *figs. 20.* 1902.

[8] BREUNER W., Klima und Blatt bei der Gattung Quercus. Flora **90**: 114–160. 1902.

THE GEOTROPIC RESPONSE in jointed plants is the subject of an extensive article by Miehe,[9] who has added much to the work done in this field by Kohl[10] two years ago. Tradescantia and Zebrina were used in a long series of experiments, which, however, cannot be even outlined here. Miehe believes he has shown that Kohl's conclusions are not well founded. Kohl's work seemed to show that two nodes were necessary for bending, the upper acting as a perceptive region while the lower was responsive. Thus in a cut portion of stem the apical node did not bend, but bending occurred in all nodes behind this. Miehe's explanation of this and other observed phenomena is that we have here to deal with an inhibition of the geotropic response in the node nearest the cut. He shows that various other factors will influence the geotropic response in a similar way. Three terms are proposed to describe these and kindred phenomena: *katatonus*, to denote a checking of power to respond normally; *anatonus*, an acceleration of this power; and *metatonus*, a complete reversal of the response. From the present paper it may be regarded as certain that the case is at least not so simple as was thought by Kohl.— BURTON E. LIVINGSTON.

HEGI[11] presents the historical features of the flora of a limited area lying within the cantons of Zurich, St. Gall, and Thurgau, Switzerland. The Miocene fossils indicate a subtropical climate at that time, while the plant remains associated with the interglacial beds record the climatic and floristic changes incident to the Pleistocene conditions. After the final retreat of the ice-sheet the associated non-glaciated areas contributed the various species which characterize the area in question today. The "xerothermische" floristic element from the Mediterranean region was at first perhaps the most effective, since the extreme cold of the Pleistocene times was apparently followed by a period of aridity and comparatively high temperatures. With the advent of the present climatic conditions the "silvestre" element (forest trees and associated vegetation) from the region northeast of the Caspian sea, became the dominant vegetative covering of the area. A third element of the flora is the class known as "glacial relicts" which, while numerous as to species, is limited as to distribution and the number of individuals. A considerable portion of the paper is given over to an annotated list of the present flora, which is based largely upon the author's personal collections and observations.— J. M. WESTGATE.

INTERESTING STUDIES on the effect of centrifugal force upon seeds and plants, with respect to both the arrangement of cell parts and the later effect

[9] MIEHE, HUGO, Ueber correlative Beeinflussung des Geotropismus einiger Gelenkpflanzen. Jahrb. Wiss. Bot. **37**: 527–593. *pls. 12, 13a, 13b.* 1902.

[10] KOHL, F., Die paratonischen Wachsthumskrümmungen der Gelenkpflanzen. Bot. Zeit. **58**: 1–28. *pls. 2.* 1900.

[11] HEGI, GUSTAV, Das obere Tösstal und die angrenzenden Gebiete floristisch und pflanzengeographisch dargestellt. Bull. Herb. Boiss. II. **1**: 179. 1900; **2**: 216. 1901, 1902.

upon growth have been made by Andrews[12] in the Leipzig laboratory. A centrifugal force equal to 1,400 times the force of gravity was used. Seeds subjected to this force for three or four hours were found to have their cell contents displaced. The nucleus is always of higher specific gravity than cytoplasm and cell sap, while oil drops are of lower. Starch and proteid grains, chloroplasts and chromoplasts, have, of course, a relatively high specific gravity. The cell contents of seeds so treated gradually return to their original arrangement, but in case the seeds are kept dry this process may take several months, whereas if they are planted in moist saw dust the normal condition is usually reached within a day or two. When the return of the cell contents to their usual position is slow, growth seems to be retarded also. The contents of sieve tubes can be extruded by this centrifugal force, but are reformed in time, the reformation going on twice as rapidly in light as in darkness. The methods described are apparently very good and we hope to gain more knowledge along these lines. Perhaps quantitative measurements made in this field may at length give some insight into the physics of cytology.— BURTON E. LIVINGSTON.

IN A RECENT PAPER Dr. Harshberger[13] reports additional observations along the New Jersey coast, incorporating in the article the results of Dr. T. S. Githens's study of the Absecon beach strand, and promising a future paper on mutation in *Hibiscus Moscheutos* L. Corn was found in the drier regions of a salt meadow at Holly beach. Along Barnegat bay wind-swept hollows occur which, when sufficiently deep to reach wet sand, are characterized by a swamp flora. Maps aid greatly in obtaining a clear idea of the distribution of species in these wind sweeps, but have the disadvantage of requiring a double translation of their legends. The appearance of fungi is accounted for by the presence of drift-wood under the dunes. *Ruppia maritima* L. found in Barnegat bay appears to be the only aquatic which can endure the alternation of fresh and salt conditions caused by the occasional entrance of the ocean through passages across the peninsula. Near Piermont occur the highest dunes of the New Jersey series (40–50 feet), back of which lies a deciduous forest. Lianes of the covered forest continue to grow upon the dune which destroyed their original support. At Sea Side Park, on account of the absence of trees, the prevailing west wind gives to the dunes a steep seaward face. The shape of the coastal trees is considered to be due more to sand-blast action than to the salt wind.—LAETITIA M. SNOW.

FIVE PAPERS dealing with the chemistry of plant life have recently been published by K. Aso. In the first of these,[14] it is shown that manganese

[12] ANDREWS, F. M., Die Wirkung der Centrifugalkraft auf Pflanzen. Jahrb. Wiss. Bot. **38**: 1–40. 1902.

[13] HARSHBERGER, J. W., Additional observations on the strand flora of New Jersey. Proc. Acad. Nat. Sci. Phila. **1902**: 642–669.

[14] ASO, K., On the physiological influence of manganese compounds on plants. Bull. Coll. Agric. Imp. Univ. Tokyo **5**: 177–185. *pls. 14–17*. 1902.

compounds in very weak solution act as a stimulant upon radish, barley, wheat, and pea. This action was manifested in culture solutions containing manganous phosphate in a concentration of 0.002 per cent.

In the next two papers[15] experiments with sodium fluorid and sodium silico-fluorid are reported. Both of these substances show a stimulation effect in very great dilution, but the latter is a much more violent poison than the former.

In the fourth paper[16] oxidizing enzymes of plants are considered. Besides the guaiac reaction for these enzymes and that with guaiacol and hydrogen peroxid, the author was able to obtain from many vegetable tissues the reaction of Storch with paraphenylendiamin and hydrogen peroxid. He also found a new reaction for oxidizing enzymes, namely, the production of a deep violet color on addition of tetramethylparaphenylendiamin and hydrogen peroxid, a reaction which was obtained from various plant tissues. Sodium fluorid and silico-fluorid interfere with the color reactions of these tests, as does also tannin, but not sugars. By addition of two volumes of absolute alcohol to one volume of plant juice, oxidase is precipitated, while most of the other oxidizing enzymes are left dissolved.

In the fifth paper,[17] the various forms of calcium in plants are treated. In potato and buckwheat only a small amount of lime compounds soluble in water are present, while in barley and clover they are more abundant. It appears that the amount of lime increases with the increase of chlorophyll.—BURTON E. LIVINGSTON.

J. C. SCHOUTE has been investigating the morphology of the stelar system of the higher vascular plants.[18] His studies relate to the histogenesis and comparative anatomy of the tissues in the flowering plants, and the work is divided into two corresponding parts.

In the first part the author describes his investigations on the structure of the stem-apex and root-apex in a number of angiosperms, and comes to the conclusion that the meristematic layers of Hanstein, the dermatogen, the periblem, and the plerome do not correspond at all accurately to the division of the tissues of the vascular plants into epidermis, cortex, and central cylinder, as proposed by Van Tieghem and others. He further finds that there is too much inconstancy in the cell wall reticulum of the growing point, especially in the case of the stem, for it to be regarded as of very great value as a clue to the morphology of the tissues. The author uses exceptionally

[15] ASO, K., The action of sodium fluorid upon plant life. *Ibid.* **5**: 187–195. *pls. 18–19.* 1902.

————, On the action of sodium silico-fluorid upon plants. *Ibid.* **5**: 197–198. 1902.

[16] ————, On oxidizing enzymes in the vegetable body. *Ibid.* **5**: 207–235. 1902.

[17] ————, On the different forms of lime in plants. *Ibid.* **5**: 239–242. 1902.

[18] SCHOUTE, J. C., Die Stelar-Theorie. Proefschrift, Groningen, December 1902.

exact methods in the study of the growing point, and takes great pains to secure exactly median and very thin sections.

In the second part he describes his examination of the stems of a large number of dicotyledons and monocotyledons, for the presence of an endodermis (phloeoterma of Strasburger), and from his own observations and the literature of the subject draws up a comprehensive tabular view of the occurrence of this layer. He finds, contrary to Fischer, that an endodermis is a very constant feature of the stem in monocotyledons, being present in 18 families out of 19 investigated. In the case of the dicotyledons, it was present in 99 out of 169 families. The author draws the conclusion that the endodermis is a very important layer morphologically. Taking into consideration the recent work on the ontogeny of the central cylinder, he agrees with Boodle, that the central cylinder of all vascular plants is morphologically the same, viz., monostelic.—E. C. JEFFREY.

WILLIS,[19] in continuing his studies of the oriental Podostemaceae, has published a most interesting account of the habits and ecological relations of the Ceylonese and Indian forms. All members of the family live in rapidly moving water, usually in the rapids and waterfalls of mountain streams. In general they are attached to rocks, each species affecting a particular habitat, determined by speed, depth, and roughness of the water. These various factors are fully described under each species. The most problematical and characteristic structure of the group is the so-called "thallus," a creeping dorsiventral organ developed from the primary axis, and itself bearing endogenous secondary shoots. In different genera the thallus seems to be of different morphological value, but in the main it has been regarded as a root structure, which raises a question as to the essential character of a root. In any event, the function of the thallus, which often resembles an alga, a lichen, or a liverwort, is to spread rapidly over rocks, developing new shoots at short intervals, and holding them in the swiftly running water until they can form holdfasts of their own.

Probably the most significant part of the paper is the discussion of the dorsiventrality of the group, no other family above liverworts showing so marked and far-reaching a dorsiventrality in organization. The author presents a series of forms passing from the least modified forms, in which dorsiventrality is only expressed by the position of the thallus, to the most highly modified forms, in which dorsiventrality appears in every part, even in the embryo. The very interesting conclusion is reached that, as in the whole family dorsiventrality appears first in the vegetative organs and then includes other members, the dorsiventrality of the flowers, which is the most important diagnostic feature of the family, is a direct result of that of the vegetative organs; in other words, that the dorsiventrality of the floral organs has been

[19] WILLIS, J. C., Studies in the morphology and ecology of the Podostemaceae of Ceylon and India. Ann. Roy. Bot. Gardens Peradeniya 1: 267–465. *pls. 4–38.* 1902.

forced upon them by that of the vegetative organs, without any reference to the advantages or disadvantages to be derived from it in the performance of the functions of the floral members themselves. The whole paper, accompanied by its numerous well-executed plates, must be read in order to get its full bearing upon several important problems.—J. M. C.

ITEMS OF TAXONOMIC INTEREST are as follows: P. HENNINGS (Hedwigia 41:295–311. 1902) has described the new genera *Capnodiopsis* (Capnodiaceae) and *Pseudobeltrania* (Dematiaceae), from the Puttemans's collection of the fungi of São Paulo, and also (Beiblatt Hedw. 41: 209–215. 1902) a new genus (*Battareopsis*) of Secotiaceae from the Schweinfurth Egyptian collection of 1901–1902.—R. CHODAT and E. WILCZEK (Bull. Herb. Boiss. II. 2: 527. 1902) have described a new genus (*Oligocladus*) of Umbelliferae (Peucedani) from Argentine.—F. B. FORBES and W. B. HEMSLEY (Jour. Linn. Soc. **36**: 1–72. 1903), in the current part of their enumeration of all the plants known from China proper, Formosa, Hainan, Corea, the Luchu Archipelago, and the island of Hong Kong, enumerate 352 species of Orchidaceae, including 23 new species and a new genus (*Hancockia* Rolfe).—N. BRYHN (Nyt Mag. Naturvidensk. **40**: 204–208. *pls. 1–2*. 1902) has described a new genus (*Sarconeurum*) of mosses (Pottiaceae) from the antarctic collections made on the Borchgrevink expedition of 1898–1900.—A. P. MORGAN (Jour. Mycol. **8**: 169. 1902) has described a new genus (*Sporocystis*) of Tuberculariaceae from Ohio, and has also (*idem* 179–192) published a list of the Discomycetes of the Miami valley, Ohio, including 128 numbers, 7 of them being new species.—J. B. ELLIS and E. BARTHOLOMEW (*idem* 173–178), in describing 23 new species of fungi from various localities include a new genus (*Stachybotryella*) near Stachybotrys, from Austin, Texas.—ANNA MURRAY VAIL (Bull. Torr. Bot. Club **29**: 662–668. *figs. 7*. 1902), in her sixth "Study" of Asclepiadaceae, has defined and illustrated 7 species of Rouliniella, 3 of them being new.—L. M. UNDERWOOD (*idem* 669–679), in his fifth paper on American ferns, has published a review of Danaea, recognizing 12 species, 5 of which are new.—P. A. RYDBERG (*idem* 680–693), in his ninth "Studies on the Rocky Mountain Flora," has taken up the Nyctaginaceae, describing new species of Abronia (6) and Allionia (3), and establishing a new genus (*Allioniella*) on *Allionia oxybaphoides*.—ALICE R. NORTHROP (Mem. Torr. Bot. Club **12**: 1–98. *pls. 1–19*. 1902), in her account of the flora of two of the Bahama islands (New Providence and Andros), includes two new genera of palms (*Paurotis* and *Cyclospathe*) described by O. F. Cook, besides new species of Aletris, Hymenocallis, Vanilla, Pithecolobium, Cassia, Linum, Erythroxylon, Crassopetalum, Helicteres, Xylosma, Terminalia, Metastelma, Heliotropium, Tecoma, Catesbaea, Myrstiphyllum, Anguria, and Eupatorium; also a new species of Thrinax by O. F. Cook, and of Phoradendron by I. Urban.—KARL MÜLLER (Bull. Herb. Boiss. II. 3: 34–44. *pl. 1*. 1903) has described several new species of Scapania from North America.—J. M. C.

RECENT CONTRIBUTIONS TO AMERICAN PHYTOGEOGRAPHY: the Central United States. W. L. BRAY published in this journal (BOT. GAZ. **32**: 99–123, 195, 217, 262–291. 1901) a most valuable paper on the ecological relations of the Texas vegetation.—W. H. LONG'S work on the distribution of fungi about Austin, Tex., has been previously noted (BOT. GAZ. **30**: 429. 1900).—C. H. FITCH (U. S. Geol. Surv. Ann. Rept. **21**: 603–672. 1900) has given a detailed description, section by section, of the woodlands of Indian Territory. —K. K. MACKENZIE and B. F. BUSH, in their manual of the flora of Jackson county, Missouri, previously mentioned in this journal (BOT. GAZ. **34**: 310. 1902), list a number of ecological habitats with their characteristic species.—J. M. WESTGATE (Science **15**: 462. 1902) traces the genetic development of the vegetation on an island in the Kansas river, giving the results of a four years' study. There have been rapid changes from xerophytic to mesophytic conditions, and these changes have been recorded by serial photographs. The actual succession of plants, as witnessed from year to year, confirms comparative studies made elsewhere.

B. SHIMEK (Proc. Iowa Acad. Sci. 7: 47–59. 1899) discusses in a most suggestive manner the distribution of forest trees in Iowa. He reviews the various theories that have been supposed to account for the treelessness of prairies, giving in footnotes a large number of citations. The fire theory has had the larger number of adherents; too much emphasis has been given to this cause, but the author thinks it of some value. Lesquereux's swamp theory explains some prairies, but not those on loess hills. Insufficient atmospheric moisture is of much importance, but cannot explain the alternation of prairie and forest in eastern Iowa. The soil character has some place. The author rightly holds that most writers have erred chiefly in holding to one theory, and discarding others. He accepts all of the above theories as of more or less value, and adds some further notes on the influence of wind, which he thinks has been too little dwelt upon. This, Shimek holds, explains the preponderance of trees in eastern Iowa, where the winds are less vehement. The wind theory accounts for trees in sheltered situations along streams, also for their relative absence on the Iowa side of the Missouri river, as compared with the Nebraska side. Tree planting experiments yield similar data.—L. H. PAMMEL (Pharm. Rev. **19**: 117, 156. 1901) gives the northern limits within Iowa of several trees of southern range, and in his *Grasses of Iowa* (see BOT. GAZ. **32**: 429. 1901) discusses the pastures, meadows, and weeds of the state, chiefly from an economic aspect.

ROSCOE POUND and F. E. CLEMENTS'S admirable Phytogeography of Nebraska has been previously reviewed in this journal (BOT. GAZ. **25**: 370. 1898; **32**: 374. 1900).—C. E. BESSEY (Forester **6**: 240–243. 1900; see BOT. GAZ. **31**: 133. 1901) has treated in an interesting manner the natural spreading of timber areas in Nebraska. He finds that the pines in the northwest, and the deciduous trees in the east are extending their domain with some rapidity. This he attributes chiefly to the restriction of prairie fires in

recent years. The pines spread easily without the aid of other plants, but the deciduous trees come up under a cover furnished by roses, plums, and other shrubs; these in turn are preceded by herbaceous plants. The same author (*idem* 7: 314–319. 1901) discusses the distribution of twenty native forest trees of Nebraska. As Professor Bessey has previously shown, most of these trees have doubtless migrated from the east along the Missouri river; probably more than fifty species have entered the region in this way, while but ten species have migrated eastward from the mountains. The maps, especially those showing the oaks and hickories, are very suggestive. The author has considered the same subject more fully in another paper (Nebr. State Board of Agric. Ann. Rept. 1899: —. 1900). In the fifteenth annual report of the botanist (1901), entitled "Some Agricultural Possibilities of Western Nebraska," Professor Bessey gives an account of the physical features and the vegetation of the sand hills and foothills. In the sand hills there are twenty-four species of trees, mostly of eastern affinities, and growing chiefly in cañons or along the rivers. Forty-eight shrub species occur, twenty of which are of western affinities. The grasses are fully considered. In the foothills there are twenty species of trees occurring on the ridges and in the cañons. More western forms (but not a majority) are found than in the sand hills. Professor Bessey (Science 14: 185–187. 1901) gave an itinerary for botanists en route to Denver, showing what could be seen from the car window in Nebraska. He also (*idem* 721–724) wrote concerning the early winter colors of the plant formations on the plains, noting the wide range of color aspects and the color tendencies of various formations.—W. L. HALL (Forester 7: 188–193. 1901) tells of the interesting tree planting experiments being made in Nebraska.—J. J. THORNBER (Bot. Surv. Neb. V. 1901) has made a statistical study of the prairie-grass formation in region I, near Nebraska City. Physical data of various sorts were collected, phenological observations were carefully made, and the various habitat-groups were studied. An interesting point brought out in the discussion of ecological factors is the much more favorable light relation in woods than in thickets. The body of the paper is on the structure of the formation, in which the controlling species are mentioned in the different habitats. A feature of the paper (wanting in many studies because an account of a region is made as a result of a week's study) is the presentation of the aspect of the prairie, season by season (prevernal, early vernal, late vernal, early estival, late estival, serotinal). A vast number of counts and diagrams of individuals in selected quadrants completes the paper.—G. G. HEDGCOCK (*idem* VI, 1902) has studied the relation of the water content of the soil to certain plants, principally mesophytes. Among other results he finds that plants wilt and die in saline soils, while the per cent. of water is still relatively high, whereas in sand the per cent. of water at which plants wilt or die is lower than in other soils. Seedlings grown in sand are more turgid than those grown in humus. The most watery plants are often the least vigorous.

Dying xerophytes contain but little water; while dying hydrophytes contain much; hydrophytes lose water more rapidly than the soil, xerophytes less so. The per cent. of non-available water in a soil increases as the square root of the per cent. of the soluble salts.

W. A. WHEELER (Minn. Bot. Stud. 2: 353–416. 1900) has written an ecological account of the vegetation of southeastern Minnesota. He notes a wide difference between the vegetation of river and creek valleys. The north-facing slopes, as so often is the case, have the climax vegetation of the region. The moist cliffs contain some rare mountain plants, and some southern trees find here their northern limit. The same author (*idem* 569–600. 1901) has presented a contribution dealing with flora of the Red river valley in Minnesota. Some interesting halophytes and semi-halophytes are recorded. Both articles are most beautifully illustrated with heliotypes, which are fully described.— D. LANGE (*idem* 621–630. 1901) gives an account of the revegetation of Trestle island in Lake Phalen, Minn. This island was exposed in 1898 and its successions of forms for three years are recorded.— B. FINK (*idem* 657–709. 1902) continues his study of the lichens of Minnesota, dealing here with those of the northwestern portion of the state. Lists of characteristic species of sixteen rock, tree, and soil formations are given, together with the characteristic adaptations. He discriminates between granitic and limestone formations, and between exposed and shaded portions in each; between rough and smooth-barked trees; between live, dead, and rotten wood; between upland and swamp trees (this seems especially interesting, since Usnea dominates in each case, but with a much greater luxuriance in tamarack swamps), etc. The author thinks that light and moisture are much more important factors in lichen distribution than are either chemical or physical characters of the substrate. It is to be hoped that many more such papers will be published, as the reviewer believes that lichens are the most favorable of all plants for working out problems of distribution. —J. M. HOLZINGER (Plant World 4: 185–187. 1901) notes some interesting cases of the local distribution of mosses in southeastern Minnesota, far from their normal range. This occurrence is in the driftless area, and these plants may well be relicts from preglacial days.— H. B. AYRES (U. S. Geol. Surv. Ann. Rept. 21: 673–689. 1900) has discussed from an economic standpoint the timber conditions of the pine region of Minnesota. An excellent map accompanies the paper.— H. C. COWLES.

NEWS.

PROFESSOR C. R. BARNES has returned to his post after a vacation of nine months. In the course of travel he visited many of the botanical establishments of Europe.

DR. J. C. ARTHUR was granted leave of absence by Purdue University and spent January and part of February at the New York Botanical Garden in studying the genera and generic types of the Uredineae.

DR. KARL GUSTAV LIMPRICHT, the bryologist, died October 20, 1902, at the age of 68 years. His monumental work is the uncompleted *Laubmoose Deutschlands Oesterreichs und der Schweiz*, of which, however, only supplementary parts remain to be published.

MISS LOUISE BRISBIN DUNN, tutor in botany in Barnard College, Columbia University, died suddenly of heart disease early on the morning of December 18. She was a graduate of Barnard and since her graduation has been a member of the teaching staff. — *Science*.

MR. A. E. DICKEY of Indianapolis has recently endowed the biological library of De Pauw University. The endowment is in the form of a memorial to Mr. Dickey's father, the late Governor Alfred Dickey, of North Dakota, and the library will hereafter be known as the Alfred Dickey Biological Library. Mr. A. E. Dickey is a graduate of De Pauw University of the class of '94.

MESSRS. HENRY HOLT & CO. announce that Kerner and Oliver's *Natural History of Plants* will no longer be published in four parts, but that in future it will be issued in a lower priced edition in two volumes. The new edition will lack only the colored illustrations of the former more expensive one, which were inserted mainly for embellishment, but retains all the other illustrations, which were an essential part of the work.

AT THE last convocation of the University of Chicago it was announced that a gift of $20,000 had been made to increase the biological library, which now numbers only about 12,000 volumes. The money being immediately available, a committee is already directing the expenditure. All imperfect sets of periodicals will be completed as far as possible, new series will be purchased and maintained, and the balance will be applied to the purchase of single works. The gift will greatly improve the library facilities in the biological departments.

ONE OF THE recent important investigations undertaken by the Bureau of Forestry, U. S. Department of Agriculture, is a study of the relationship of forests to stream-flow in the Rock River watershed of Illinois and southeast-

ern Wisconsin. For some years a marked decrease has been noticed in the flow of this river, especially during the more critical parts of the summer and autumn. The investigation which the Bureau of Forestry made of this watershed shows that the diminished flow of the river can be traced to several distinct causes. The most important of these are the changes that have taken place in the area and the condition of the forests.

THE BOARD OF TRUSTEES of the Carnegie Institution has made an appropriation of $8,000 for the establishment and maintenance of a desert botanical laboratory for the fiscal year 1902–3, and at the request of the Executive Committee of the Institution Dr. D. T. MacDougal, Director of the Laboratories, has been permitted to serve with Mr. Frederick V. Coville, Chief of the U. S. Department of Agriculture, as an advisory board in relation to this undertaking.

The desert laboratory has been established for the purpose of making a thorough investigation of the physiological and morphological features of plants under the unusual conditions to be found in desert regions, with particular reference to the relations of the characteristic vegetation to water, light, temperature, and other special factors.

A resident investigator, to be placed in immediate charge of the laboratory, will begin a series of researches upon certain more important problems outlined by the board, and facilities will be provided by the aid of which a few other investigators from any part of the world may carry on work upon any problem connected with desert plants.

North America contains more than a million square miles of territory known to the geologist, geographer, and botanist as desert. The conditions offered vegetation in these districts show such wide departures from those of humid temperate and tropical regions, the living flora is accessible to so few workers, and the entailed investigations are necessarily so wide in scope, and so expensive and difficult in execution, that the advance of systematic knowledge of the fundamental processes of desert plants has been comparatively slow, and this lack of information has made many current generalizations concerning the activity of plants very unsafe. The establishment of this laboratory promises results concerning the fundamental processes of plant protoplasm as important as any in the whole realm of botany, and withal results which once known and incorporated in the science of botany might well offer facts of the greatest value not only to the inhabitants of the arid regions of America, but to the people of other desert regions as well, since no similar inquiry has yet been instituted in any part of the world. — *Jour. N. Y. Bot. Garden.*

DR. W. A. CANNON has been selected as resident investigator of the Desert Botanical Laboratory of the Carnegie Institution. Mr. Frederick V. Coville and Dr. D. T. MacDougal started on January 24 to make an inspection of the region along the Mexican boundary from the Pecos river in Texas to the Pacific Ocean, for the purpose of fixing on a site.

THE GATHERING of botanists at Washington during "Convocation Week" was the largest that has ever occurred in the history of this country. Besides the meetings of Section G, A. A. A. S., and its informal Botanical Club, meetings were held of the Society for Plant Morphology and Physiology and of the Botanical Society of America. Over one hundred professional botanists were registered, and it is safe to say that at least fifty others more or less directly interested in botanical matters were in attendance.

Before Section G, Mr. F. V. Coville presiding, the retiring president, Dr. D. H. Campbell, of Leland Stanford University, gave an address on "The evolution of land plants." About twenty five papers were admitted to the program and read in full or by title. The sessions closed on Wednesday. Professor T. H. Macbride was elected president for the next meeting, which is to be held in St. Louis December 28, 1903–January 2, 1904. Dr. F. E. Lloyd was elected secretary for five years.

The Society for Plant Morphology and Physiology met on Tuesday and Wednesday. Eighteen papers were read in full; seven others were presented by title. The proposed central bureau of the Association Internationale des Botanistes was discussed, and the decision was unanimous that the proposed bureau would not be useful in proportion to its cost and the labor of maintaining it. The following were elected members: W. A. Cannon, New York Botanical Garden; Judson F. Clark, Cornell University; G. P. Clinton, Connecticut Experiment Station; W. C. Coker, University of North Carolina; C. C. Curtis, Columbia University; E. J. Durand, Cornell University; J. E. Kirkwood, Syracuse University; W. A. Orton, Department of Agriculture, Washington; K. M. Wiegand, Cornell University. Dr. Roland Thaxter, of Harvard University, was elected president; Professor Conway MacMillan, of the University of Minnesota, vice-president; and Professor W. F. Ganong, of Smith College, secretary-treasurer. Thirty-five members were in attendance.

The Botanical Society of America met on Wednesday afternoon and Thursday. The retiring president, Dr. J. C. Arthur, of Purdue University, gave an address, illustrated by lantern slides, on "Problems suggested by cultures of the Uredineae." Forty papers were read in full or by title. No new members were elected on account of the defective report of the committee on membership. A committee was appointed to confer with similar committees from other botanical societies, for the purpose of securing cooperation and, if possible, federation. Dr. C. R. Barnes, of the University of Chicago, was elected president; Mr. J. N. Rose, of the U. S. National Museum, vice-president; Dr. D. T. MacDougal, of the New York Botanical Garden, secretary; and Dr. Arthur Hollick, of the New York Botanical Garden, treasurer.

The botanists of the central states organized themselves into a society, electing Professor Conway MacMillan, of the University of Minnesota, president, and Dr. C. F. Millspaugh, of the Field Columbian Museum, Chicago, secretary. Arrangements for the next meeting are left to an executive committee.